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NATIONAL PARK SERVICE - SOUTHEAST REGION

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EIGHTH ANNUAL SCIENTIFIC RESEARCH MEETING

June 24-25, 1982

Tremont Environmental Education Center
Great Smoky Mountains National Park
Townsend, Tennessee

Compiled and Edited by Jim Wood
Production Assistant: Kathy Turner

U.S. Department of the Interior
National Park Service
Southeast Regional Office
Natural Science and Research Division
75 Spring St., S.W.
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ABOUT THE COVER

UPLANDS FIELD RESEARCH LABORATORY
Great Smoky Mountains National Park

The Uplands Field Research Laboratory is directly affiliated with the Great Smoky Mountains National Park and is financially supported by the park and the science program of the National Park Service. The laboratory serves as a focal point for scientific research in the Smokies and other upland national parks in the Southeast Region.

Research Coordination. The laboratory uses a variety of tools to coordinate research in the park. This is necessary to minimize environmental impact to park resources and encourage scientists to address the park's research priorities. Research and collection permits are issued to researchers, after clearance concerning environmental impacts and interface with other research projects. Cooperative agreements have been established with several universities and other federal and state agencies to share resources. The laboratory's facilities are available to outside scientists conducting priority research. The laboratory hosts an annual science seminar that provides researchers with the opportunity to share and exchange information on project methods and findings.

Baseline Data. A special study sponsored by the United Nations' Man and the Biosphere (MAB) program has provided guidance in defining the baseline date needs for Great Smoky Mountains National Park. The laboratory is working to fill the identified gaps in available data.

Resource Monitoring. As a Biosphere Reserve, Great Smoky Mountains National Park has become a focal point for monitoring environmental change. Monitoring trends is particularly rewarding in the Smokies since the area has been studied by natural scientists for over 50 years. Several monitoring stations are presently operational in the park. A complete listing of parameters measured and procedures necessary to access the accumulated data is available upon request.

Research. The laboratory conducts research projects which address specific environmental threats or management concerns. Projects have incorporated a wide variety of scientific disciplines and subject areas. Study results are presented in the Research/Resources Management Series published by the Southeast Regional Office of the National Park Service and in various journals and conference proceedings. Laboratory publications are available upon request.

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Management Application. Laboratory scientists interpret research results for park management. Assessment of the environmental impacts of proposed management practices is routinely conducted as well.

# # #

Cover art: Pen and ink rendering of the Uplands Field Research Laboratory by David Wallach of Flushing, New York. David is a student at Antioch College.

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WELCOME

Merrill D. Beal
Superintendent
Great Smoky Mountains National Park
National Park Service

This is the fourth such conference I have been privileged to share with you. On behalf of the U.S. Department of the Interior, the National Park Service, and Great Smoky Mountains National Park, I welcome you to this opportunity to share and learn.

John Peine told me that I should say something profound to you, and I advise you to listen closely so you won't miss it!

I do have some observations to make on the usefulness of science programs. Traditionally, research in the national parks has been done in search of knowledge for its own sake. National parks are excellent outdoor laboratories and attract researchers. Our response was opportunistic and involved finding common ground with scientists and sharing resulting information. Over the years this relationship was mutually rewarding and knowledge increased substantially and was incorporated in interpretive programs and resource management activities.

More recently, however, science has been strongly supported and resources allocated for the express purpose of developing knowledge to help resolve management problems related to planning and development, resource management, interpretive information and visitor use.

For a time it appeared that some managers believed science to be the answer to all problems, and dependence on such studies for planning efforts and program implementation led to long-term efforts, which could be at least partially responsible for Secretary Watt's observation about "paralysis by analysis."

But research produces data and information, not necessarily solutions. We should not expect it to do much more. Recommendations may be made, but objections are frequently raised. Interest groups, individuals, and other levels of government have access to science information, too, and occasionally retain their own "hired guns" to dispute us.

When researchers or scientists with access to the same data base arrive at highly conflicting interpretations, it is wise to reflect on whether the differences are scientific or ideological.

In this new era of public involvement in government activities, we need the best science we can afford. But with or without research efforts, you can depend on the following "Beal's generalization," submitted with full knowledge of Oliver Wendell Holmes' caveat that "no generalization is worth a damm, including this one." It is:

Those who disagree with any significant management decision will attack it at any level possible. A "hierarchy of vulnerability" is being established.

Let me illustrate:

Situation:	Attack:
1. Attempts to manage intuitively or in compliance with law and policy	Accusations of authoritarian and arrogant conduct.
2. Corrective measures to remedy observed complications or effects	Insufficient data base to justify.
3. Managers have some knowledge, but seek funding for more work	Belittle efforts, stress "common knowledge," award "golden fleeces."
4. Extensive data but differing interpretations	Expand or prolong study.
5. Conclusive or absolute evidence	Political appeal - change law or make exception.

You can see it is a "no win" proposition!

Timing and procedure may be more important than scientific fact in getting acceptance of change in our society.

Increasingly, a burden of proof is placed upon government that it is not possible to properly discharge. There is not enough time, money, or expertise available to us. Additionally, most problems cannot be resolved to the satisfaction of all parties, and our democratic system of government supports this.

A politician can be nominated by a simple majority of his fellow party members, he can be elected by a bare majority of the voters. He and others similarly selected can pass a law with a majority vote of the legislative body. At that point the career bureaucrat takes over. He and his kind are expected to implement the new law and satisfy everyone, including those opposed it from the beginning.

By this process we have armed the public and interest groups with an arsenal of political and legal weapons, all well intended, with which to delay, obstruct and often defeat necessary resource preservation efforts.

These valuable, but frequently abused, two-edged weapons include but are not limited to:

Freedom of Information Act
Privacy Act
National Environmental Policy Act
Historic Preservation Act
Endangered Species Act
Clean Air Act, and others.

Management-oriented science seems to be moving in the direction of the legal system (perhaps forced to do so by the laws cited). The approach is best described as adversary as opposed to refereed - and it is one in which technicalities and "winning" may be improperly substituted for the goal of a search for knowledge.

Let me offer my fervent hope that we do not let this happen! This conference is a time for constructive dialog and learning - we can all grow in our disciplines and better serve our employers as a result.

Welcome to the Eighth Annual Uplands Scientific Research Meeting.

OPENING REMARKS

Stuart E. Coleman
Resource Management Specialist
Great Smoky Mountains National Park
National Park Service

I wish to add my welcome to that of the Superintendent, and this year welcome not only the participants, but also John Peine, the new director of Uplands Field Research Laboratory. John has inherited a very dynamic and productive facility that has become a vital function in this park. Under John's leadership, we in Resource Management look forward to a continued harmony of the resource management and research effort here.

Park management faces the formidable task of managing this park, the largest area of wilderness in the East, in a natural state. We are charged with managing for the protection and preservation of its natural and cultural uniqueness and the often-forgotten use and enjoyment of this park by this generation and generations to follow.

This natural island is to be managed in a special way, as a replica of the primitive America European man first gazed upon 400 years ago. We understand it is less than perfect, that it is only a close approximation, and that it is only a reasonable illusion of the desired pre-Columbian setting, but our combined endeavors must continue to strive for that perfection.

There are inherent management problems perpetrated by this National Park Service philosophy and policy mandate. The park obviously cannot be managed in a vacuum and without the scientific sophistication of information gathering, analysis and recommendations. Important and timely information must be provided to the Resource Manager if the mandate is to be fulfilled. Ecological baseline data must be collected; user patterns, perceptions, preferences and impacts assessed; and the discovery and quantification of external threats and their role as modifiers to natural systems spelled out before mitigating strategies can be developed to extract the hand of technological man in the Smokies. We must know what aspects of the ecosystem require rectifying before the work can commence.

But a cautionary note: the research and/or resource management work to be completed must be well conceived before implementation. The act of obtaining the information must not compromise the very values we judiciously guard. These research manipulations and impacts must be carefully weighed against the worth of the information to be obtained. Good research projects integrate a minimum pact strategy in their proposals.

Resource managers and researchers do an excellent job at communicating with each other--but I wonder what kind of job we do with the public. Unless we turn good science into good reading, we may not be communicating to our fullest potential. We must strive to inform the general public of our concerns and accomplishments if the current direction of natural area preservation and national parks is to be maintained. These unique natural areas must remain viable genetic pools of what once was. Unless we package and market our concerns for the flora and fauna and the general assault on the natural world, it may soon be a case of "too little, too late."

We must also create that awareness among top managers and politicians, and they must realize the trade-offs that occur as a result of environmental degradation. Parks such as the Smokies serve as an international indicator of the health of the world's natural systems. Recently, S. David Freeman, Director of the Tennessee Valley Authority, returned from a symposium in London which was devoted to global environmental policy. He made this statement to the Knoxville newspaper: "Preliminary indications are that acid rain, caused by emissions from coal-fired steam plants, may be even more serious than we fear at the moment." At least the awareness is now there. It is most important that our messages reach the critical decision-makers.

Well, I am excited about the topics on the agenda this year and join in wishing this to be a most productive conference.

THE ART OF TECHNICAL WRITING: SOME PERSONAL OBSERVATIONS AND GUIDELINES

Jim Wood
Technical Publications Editor
National Park Service
Southeast Regional Office

The need for high quality in research papers has never been more evident than in today's fast-paced, complex technological age. Our minds boggle from the accelerating expansion of research and all the publications resulting from it. The practicing scientist, manager, or administrator has only limited time in trying to keep abreast of the voluminous literature. His problems multiply and intensify when that literature is verbose, vague, and boring. He deserves to read articles that are technically sound, informative well-organized, and a pleasure to read. He must be able to grasp information and ideas at a single reading, without having to re-read sentences or puzzle over ambiguities.

Although I believe the writing of many National Park Service scientists (and others) is of high quality, in my experience as an editor I have seen no manuscripts that could not be polished and improved. Some have been prepared so poorly and in such careless, sloppy language that they fell far short of the high standards on which the Service must insist. It was impossible to judge their scientific worth until they were translated into reasonably acceptable English.

Some of the best (and some of the poorest) written English I have seen is the work of technical men and women--biologists, geologists, social scientists. Technical writers, whether they realize it or not, start with an advantage. Their basic material is concrete facts and events. Their main object is to describe such and show the relationships between them.

In my judgment, the best technical writing is being done by persons at the top of their professions. They have done important work, understand its meaning, and write about it with confidence. They are bold and confident enough to write simple, direct English.

Too many others, who either haven't done much or are unsure of themselves, tend to write with an uneasiness that leads to fog. They are likely to smother their meaning in qualification and jargon. Still others are so engrossed in their work that its "special language" has become second nature to them. They overlook how awkward, bundlesome, and puzzling this gobbledygook can become when allowed to clot on paper. The scientist who is sure of himself includes, of course, qualification and specialized technical terms when required. But he also recognizes the surplus that can be safely shed. This is an important part of wisdom and essential to clear communication.

I find it ironic that:

1. Most of the scientists I know do very well in oral communication. They talk simply and clearly and can explain to a layman what they are doing. But once they begin to write they shun simple English and slip into an odd jargon they consider "traditional" and "safe." They are afraid that if they did otherwise, their writing might seem "unprofessional."

   In my opinion, it is never unprofessional in the sciences to make oneself clear!

2. Although many technical and professional people generally are poor writers, they read no better and are no less easily confused by fog than laymen. This is easy to judge from the lively oral discussions that are often printed following the dry scientific papers of technical meetings. Many scientists have told me that, to save time, they habitually skim the articles, then read closely the oral discussions!

All the foregoing doesn't mean scientists should write their reports for grade-schoolers. Neither should they write their papers as "all things to all people." Many scientists will argue that writing for scientific review (to gain publication of their work in technical journals) and writing for the "educated layman" are two different things, that it is impractical to combine both. To this I agree--but up to a point. (Remember that earlier statement that scientists read no better than laymen?) What I want to emphasize is -- any piece of writing should revolve around the intended reader. The report should be related to the reader's experience. It should prepare him for what he is about to read. It should be presented in a rational, logical manner to lead the reader's attention and enable him to gain facts and their relationships in the shortest possible time.

Any scientist who writes a paper has spent time gathering facts and contemplating their meaning. The interpretation of meaning is usually the most important part of the paper. The author owes it to the reader to make clear the meaning he has been able to draw from the facts--without neglecting to underline points that are still unclear or unsolved. This is especially important for scientists working for public land management agencies like the National Park Service--they have a clear obligation to park managers charged with the stewardship of these lands.

When a scientist writes for those outside his field he should take care to avoid or explain technical terms that are not commonly familiar. In writing for people within his own field, he should review his technical writing self-critically and ask himself these questions: Am I using these words to express or to impress? Am I using them because they are necessary to make my ideas clear or am I using them merely to signal that I am an expert?

To illustrate, here's four guidelines that will help overcome some of the most common faults found in scientific writing:

1. Arrange the material logically. Some scientists fail to organize their writing in a rational, logical order. For example, they may begin their reports in unknown specifics rather than familiar basics. It is much better to start with something the reader is familiar with and then move on, one step at a time, from the known to the unknown, or from the general to the specific. The material must be arranged so that each paragraph clearly leads to the next (i.e., A leads to B, B makes C understandable, etc.).

   Another example of poor organization occurs when one system isn't used all the way through. For instance, it's puzzling to see "feet" or "miles" in one section and "meters" or "kilometers" in another. If for some reason we need to use both systems, ordinarily we should give the familiar one first, then use parentheses to convert the figures into the other system. We shouldn't make our readers do the math!

2. Prefer the active voice. Technical writers should make a special effort to avoid a monotonous series of passive constructions, for active ones are shorter and more readable. Example:

   PASSIVE: The melting point of the alloy was lowered 50 degrees by adding 10 per cent of aluminum.

   ACTIVE: Adding 10 per cent of aluminum lowered the melting point 50 degrees.

3. Don't make nouns out of good, strong "working verbs." Making nouns out of verbs tends to smother the meaning of sentences. Example:

   SMOTHERED: Authorization must be received from the Research Director before utilization of new methods can be incorporated in this project.

   IMPROVED: The Research Director must authorize new methods before they are used in this project.

   (Why not "utilize"? Isn't that the verb form of "utilization"? Yes, it is. But "use" is shorter, crisper, and less stuffy.)

   The main trouble with smothered verbs is this: anytime you change a working verb to a noun, you must add another verb to complete the sentence. Also, you can see from the above examples that smothered verbs and passive constructions frequently go together. In fact, they are almost inseparable. If you can "unsmother" a verb and, at the same time, change a passive to an active construction, you'll cut sentence length by a third.

Why, then, should anyone want to change useful, hardworking verbs into long-winded nouns, by adding endings such as -tion, -ance, -ization, and so on? Frankly, I don't know, but it's a very popular custom in administrative as well as technical writing. (I suspect it has to do with many writers' desire to impress, to be "elegant.")

4. Be concise--cut out excess baggage. Technical writers should strive to eliminate unnecessary complexity by reducing sentence length. Example:

   ORIGINAL: Comparison of data obtained with these paints using Barco with those using Lenol revealed that use of Barco solvent slowed the drying appreciably (approximately doubling the time in most instances) but had very little effect on the viscosity characteristics obtained.

   REVISION: The data showed paints using Barco were no more viscous than those using Lenol, but dried only about half as fast.

The above guidelines do not cover every possible "poor writing" situation -- just a few of the more common ones. For those who wish to learn more, let me suggest this paperback: Writing with Precision by Jefferson D. Bates. Published by Acropolis Books, LTD., Washington, D.C. 20009. $6.95 per copy.

In these days, more than ever before, the reading time of a scientist is precious. Few of them like the task of writing. They would prefer to be in the laboratory. At the same time, writing is the chief means (and permanent record) of handing on what they have learned.

If a scientist will analyze his writing from the point of view of the reader, and if he will break away from the bad habits that have hampered the "traditional way" of much scientific writing, he will be on his way to improved, clearer writing. And the likelihood of his chances for career advancement and self-esteem will increase, for his writing will become more receptive to both supervisors and colleagues.

Remember--write for the reader, not the filing cabinet!

THE NATIONAL PARK SERVICE'S SOUTHEAST REGIONAL SCIENCE PUBLICATIONS PROGRAM: AN OVERVIEW

- - JIM WOOD, National Park Service, Natural Science and Research Division, Southeast Regional Office, Atlanta, Georgia

The National Park Service's Southeast Regional Science Publications Program is geared toward meeting three primary objectives:

1. Production of high quality, mission-oriented in-house research publications that provide essential information to guide park resource management programs;

2. Publication of National Park Service research results in outside professional journals; and

3. Transfer of both of the above to not only the parks but other agencies (federal, state, and local), universities, and independent research institutions.

Objective No. 1 is specifically designed to meet the in-house scientific information needs of park managers, resource management specialists, and other personnel at the park level. We have developed the Research/Resources Management Series and the South Florida Research Center Management/Technical Reports Series to meet this need for the parks in the Southeast Region.

Objective No. 2 is of utmost importance. When our NPS scientists publish the results of their research in outside scientific and technical journals, they gain professional credibility and standing in the scientific community. Papers submitted for publication in professional journals undergo a rigorous peer review. Acceptance for publication implies that the research methods are sound and that the findings represent a potential or real contribution to the field of knowledge in question.

We place particular emphasis on Objective No. 3 because we believe in the need to foster interagency cooperation and information-sharing. When we share and exchange our research information with other agencies, universities, and research institutions, we are able to pool common resources, keep abreast of what other scientists are doing, and prevent wasteful duplication of similar studies that have been or are being undertaken by others.

SOME MANIPULATIVE ALTERNATIVES FOR MANAGEMENT OF SOUTHERN APPALACHIAN GRASS BALDS

- - J. DAN PITTILLO, Department of Biology, Western Carolina University, Cullowhee, North Carolina

Grass balds of the southern Appalachians are continually being succeeded by woody vegetation. Earlier publications of Wells and Mark suggested 43 sites were grass balds but a more comprehensive study by Gersmehl indicated 119 sites are or have been grass balds, with 34 remaining "true balds" in his late 1960's studies.

Manipulative maintenance of the grassy balds will be required if these features are to be retained as a vegetational unit in the southern Appalachians. The methods can vary from mechanical cutting or clearing to burning, grazing,and treatment with herbicides. Each of these techniques has its advantages and shortcomings. A combination of burning and grazing, utilizing herds of bison and elk was suggested as a more natural alternative to other more artificial methods.

INVASION OF *FAGUS GRANDIFOLIA* INTO A HIGH ELEVATION HEATH BALD AT CRAGGY GARDENS, NORTH CAROLINA

- - RICHARD B. THOMAS and J. DANIEL PITTILLO, Western Carolina University, Cullowhee, North Carolina

GARRETT A. SMATHERS, National Park Service, Cooperative Park Studies Unit, Western Carolina University, Cullowhee, North Carolina

High elevation heath bald communities containing *Rhododendron catawbiense* have sometimes been considered to represent stable climax communities, possibly inhibiting hardwood invasion by allelopathic interference. Observations at Craggy Gardens, however, suggest that this high elevation heath community is receding with birch, *Betula alleghanensis*, encroaching on the northern slope and beech, *Fagus grandifolia*, invading on the southern slope. Recently, analysis of vegetation has shown that beech trees are indeed encroaching on the heath community. Aging of trees along a transect running southeast from the *Rhododendron* community also implies the invasions of *Fagus*. Further observations have indicated that this invasion of beech is occurring by means of root sprouting. As the beech roots move into the *Rhododendron* community, the rhododendron degenerates in the contact zone, opening the area to the young developing beech sprouts.

VEGETATION MAPPING AND MONITORING IN GREAT SMOKY MOUNTAINS NATIONAL PARK: A MANAGEMENT SUMMARY FOR HEATH AND GRASS BALDS

- - PETER S. WHITE, National Park Service, Uplands Field Research Laboratory, Great Smoky Mountains National Park, Gatlinburg, Tennessee

The Great Smoky Mountains (GRSM) vegetation survey and monitoring began in 1975. Initial plot establishment was organized around short-term management questions such as impacts of European wild boar, post-logging and agricultural succession, effects of White-tailed deer and cattle in Cades Cove, and fire effects. By 1979, some 300 .1-ha permanent plots had been established, most in the western third of the park on the Tennessee side.

In 1981-1982, the first mapping was accomplished. It is the purpose of GRSM plant ecologists to document this project by presenting management summaries by vegetation type. These will include topographic models of the types, and data of stability and flora. In this abstract I will report on two kinds of high elevation treeless communities: grassy and heath balds.

There are some 17 grassy balds in GRSM, totalling 30.5 ha or .015 percent of the GRSM landscape. Grassy balds occur on only a few of the seemingly appropriate sites and are dominantly found in the western part of the park. Grassy balds are species-rich with over 300 vascular plant species recorded (100 on some individual balds). Four species are restricted to grassy balds in GRSM. Eight additional infrequent species have important populations on grassy balds. As is well known, grassy balds are unstable and succeeding to forest. Past data allow individual species lists for five balds: Gregory, Andrews, Parsons, Silers, and Spence Field. Floristically, Gregory has the most important rare species.

By contrast, heath balds are species-poor. Only 51 vascular species have been documented (20 per individual bald). No species are entirely restricted to heath balds. There are 447 heath balds, totalling 670 ha (.33 percent of the GRSM landscape). The mean size is 1.5 ha. Heath balds are found predominantly in central and eastern GRSM (63.6 percent of heath balds on 30.5 percent of the park's total area). Only 2.4 percent of total heath bald area occurs in the western 37.5 percent of the park. Heath balds are generally found on dry exposures--97 percent are on ridges or convex slopes. The mean elevation is 4,488 ft. However, predictability of topographic models is low--less than 50 percent of seemingly appropriate sites are dominated by heath balds. Heath balds appear to be stable communities when select balds are compared in 1930s and 1970s aerial photography.

SEED DISPERSAL AND SEEDLING ESTABLISHMENT IN THE JUDACULLA FIELDS (BLUE RIDGE PARKWAY)

- - JOE H. SULLIVAN, Department of Botany, Clemson University,
Clemson, South Carolina

Seed dispersal by spruce and fir was estimated utilizing 1 m square boards coated with "Tangletrap" placed in the Judaculla Fields, a grass bald completely surrounded by spruce-fir forest, for three years (1979-81). Very few spruce or fir seeds were dispersed into the field during 1979 and 1980. During the 1981 dispersal season 163 seeds were collected. The low number of seeds collected during the first two years was attributed to consecutive poor seed production years for spruce and fir. The greater number of seeds collected during the third year indicated that occasionally adequate seed quantities reach the area to effect reforestation of the fields. Invasion by spruce and fir is occurring primarily along the northeastern and northwestern ecotonal areas.

Vegetation study plots established in the fall of 1979 and resampled each spring and fall revealed some invasion into the grassy areas by herbaceous genera (*Solidago*, *Houstonia*, *Potentilla*, *Carex*, and others) and by some woody genera (*Rubus*, *Vaccinium*, and *Abies*). Considerable mortality, greater than 30% annually, of the one to two year spruce and fir seedlings was observed. No positive or negative associations were observed between spruce or fir seedlings and other vascular species. It was concluded that establishment of spruce and fir is being slowed by physical factors rather than by competition or seed supply.

INFLUENCES ON THE HEIGHT AND AGE OF A HIGH ELEVATION NORTHERN RED OAK COMMUNITY IN THE CRAGGY MOUNTAINS OF NORTH CAROLINA

- - REBECCA BURKHEAD and JAMES H. HORTON, Western Carolina University, Cullowhee, North Carolina

GARRETT A. SMATHERS, National Park Service, Cooperative Park Studies Unit, Western Carolina University, Cullowhee, North Carolina

An oak orchard is a high elevation plant community characterized by northern red oaks (_Quercus rubra_ L. variety _borealis_ Michaeux) which exhibit reduced height and gnarled growth compared with conspesific types found at lower elevations. This study reports the age and height of an oak orchard which is located at Craggy Flats, elevation 1646 meters. Although more than two-thirds of the population studied was between 40 and 70 years of age, their average height was found to be 8.2 meters. The majority of these trees became established in the 1930's when portions of the area were fenced as a watershed by the city of Asheville. The effects of wind and low temperatures are the probable causes of the gnarled branching and reduced size of the red oaks at this research site.

HUMAN IMPACT ON TWO WOODLAND ORCHID SPECIES IN GREAT SMOKY MOUNTAINS NATIONAL PARK

- - SUSAN POWER BRATTON, National Park Service, Cooperative Research Unit, Institute of Ecology, University of Georgia, Athens, Georgia

Despite legal protection, the flora of Great Smoky Mountains National Park is still subject to human disturbances including illegal harvest (poaching) and trampling. The purpose of this study was to investigate the population structure of two species of woodland orchids, showy orchis (Orchis spectabilis) and pink lady slipper (Cypripedium acaule), known to be harvested by wildflower diggers and flower pickers. The study surveyed all the individuals of the species in question in selected study areas: 1) along easily accessible and heavily used roads and trails, 2) along moderately used back-country trails, and 3) in off-trail and difficult access areas. Measurements included the length of the longest leaf of an individual, the number of leaves, the presence of an infloresence, the distance to the nearest trail, the distance to the nearest vehicle road, and the distance to the nearest neighbor in classes of: 1) less than or equal to 10 cm; 2) greater than 10 cm, less than or equal to 1 m; 3) greater than 1 m, less than or equal to 10 m; 4) greater than 10 m, less than or equal to 50 m; and 5) greater than 50 m.

The preliminary results of the study indicate that showy orchis populations are denser along trails and roadsides and decline in numbers, but not in the maximum leaf length of the plants, with increasing distance from a trail or road. There was no indication that human poaching or trampling is presently harming park populations. In the case of the pink lady slippers, however, populations in easy access areas had smaller plants and fewer flowering individuals than those in remote sites. Average length of longest leaf for roadside and nature trail populations ranged from 5.36 cm to 10.89 cm, whereas average length of longest leaf for remote populations ranged from 11.18 cm to 19.86. The percentage of shoots flowering in easy access areas ranged from 0 to 9, whereas the percentage in remote areas ranged from 6 to 54. Although it is impossible to absolutely separate poaching from trampling effects with these methods of data collection, it is probable that human activity is removing the larger and more vigorous plants from the most accessible lady slipper populations.

FIRES EAST AND FIRES WEST: ADAPTING U.S. NATIONAL PARK SERVICE FIRE MANAGEMENT POLICY TO LOCAL FIRE REGIMES AND ENVIRONMENTAL CONDITIONS

- - SUSAN POWER BRATTON, National Park Service, Cooperative Research Unit, Institute of Ecology, University of Georgia, Athens, Georgia

Contemporary National Park Service fire management no longer emphasizes complete suppression of all fires, but allows for various forms of prescribed fire, including controlled burning and maintenance of natural fire rotations. In the past, the most active and ecologically sound fire management programs have operated in the Everglades and the larger western national parks. These areas are characterized by short fire rotations and frequent natural fires of large size (hundreds or thousands of hectares) or of high intensity. Eastern upland parks, by contrast, have longer natural fire rotations, tend to have much smaller fires, and tend not to develop heavy fuel loadings. The lesser threat of severe fires has probably inhibited development of natural fire management programs in the upland areas in the east. The eastern national seashores are, with the exception of Cape Hatteras, relatively new park areas designated during the 1960's and 1970's. These sites support mosaics of grassland, marsh, scrub and forest communities, many of which are susceptible to both natural and man-caused fire. Cape Canaveral National Seashore is ecologically very similar to Everglades National Park and will require sophisticated fire management, including controlled burning. Since its designation in 1972, about 16% of the forested area of Cumberland Island National Seashore has burned in lightning-ignited fires. Relative to their size, the national seashores have much higher fire frequencies than the upland eastern parks. Further research on the fire ecology of coastal communities is necessary to determine optimal fire management strategies for the newer coastal parks.

PLANT COMMUNITIES OF THE OBED WILD AND SCENIC RIVER

- - PAUL A. SCHMALZER and H. R. DeSELM, University of Tennessee, Knoxville, Tennessee

The forest vegetation of the Obed Wild and Scenic River has been classified into ten community types using data from 327 0.04 ha sample plots and an agglomerative hierarchical cluster analysis technique. These types are: river birch, beech-tulip poplar, tulip poplar, white oak, hemlock, sweet birch-hemlock, chestnut oak-white oak, white pine-white oak-chestnut oak, white oak-scarlet oak-pine, and Virginia pine types. Slope position, aspect, protection, and disturbance history influence distribution of the vegetation. Non-forest vegetation types include sandstone rock outcrops, riparian shrub-herb communities on gravel and sand bars, cleared areas, and abandoned strip mines. Minor vegetation types include aquatic vegetation, sandstone cliffs and rockhouses, and wet shale cliffs. A vegetation map has been prepared at a scale of 1:6000. The ten forest types, a general oak-pine type, and the four non-forest vegetation types have been mapped.

VASCULAR FLORA, ENDANGERED AND THREATENED PLANTS, AND CRITICAL PLANT HABITATS OF THE OBED WILD AND SCENIC RIVER

- - PAUL A. SCHMALZER, THOMAS S. PATRICK and H. R. DeSELM, University of Tennessee, Knoxville, Tennessee

The vascular flora of the Obed Wild and Scenic River consists of 735 taxa in 122 families. The largest families are the Asteraceae (102 taxa) and the Poaceae (82 taxa). Fifty-one introduced taxa occur (6.9% of the total). Fifteen taxa are considered threatened or endangered in Tennessee. These are: *Adlumia fungosa*, *Amelanchier sanguinea*, *Calamovilfa arcuata*, *Conradina verticillata*, *Helenium brevifolium*, *Hexastylis contracta*, *Hieracium scabrum*, *Hydrastis canadensis*, *Leucothoe racemosa*, *Marshallia grandiflora*, *Panax quinquefolium*, *Polygonella americana*, *Polymnia laevigata*, *Sporobolus junceus*, and *Talinum teretifolium*. Eight of these rare taxa (53%) are restricted to the riparian shrub-herb type. Critical plant habitats are suggested which include one sandstone outcrop, two areas of gravel bar-riparian shrub-herb community, one area of sandstone boulderfield, two areas of mesic deciduous forest, one area of wet shale cliffs and one area of floodplain river birch forest.

A PALEOECOLOGICAL ANALYSIS OF HOLOCENE VEGETATION AND ITS ENVIRONMENTAL IMPLICATIONS, LAKE IN THE WOODS, CADES COVE, GREAT SMOKY MOUNTAINS NATIONAL PARK

- - JEAN L. DAVIDSON, University of Tennessee, Knoxville, Tennessee

The Blue Ridge Mountains have areas with divergent bedrock and topography which have served as refugia for some species during times of climatic stress. Cades Cove, a limestone fenster, contains poorly drained bottomlands. Lake in the Woods is a semi-permanent woodland hollow pond on a colluvial ridge at the west end of Cades Cove. Using pollen and macrofossil analysis of a sediment core from the site, the local and extralocal vegetation of the lake has been determined. Radiocarbon analysis of the core at 25-35 cm and 65-75 cm provides dates of 6300 ± 90 B.P. and 6410 ± 70 B.P. These dates reflect rapid sedimentation rates which permit detailed resolution of the mid-Holocene vegetation of Cades Cove. Pollen from the 75 cm level indicates the presence of bottomland swamp and colluvial habitat of *Liquidambar*, *Acer rubrum*, *Nyssa*, and *Salix* with an understory of *Isoetes* and wetland fern species. Sweetgum was previously considered absent in the Blue Ridge prior to settlement. The extralocal vegetation consisted primarily of *Quercus* and included *Castanea*. Upland hardwood vegetation today has been modified by an increase in *Pinus* and the extinction of *Castanea*. The presence of perennial herbs including *Thalictrum* represents a semi-permanent wetland habitat. Changing pollen and charcoal influx levels and the vegetation changes of the lake elucidate the climatically induced changes in the topography of Cades Cove. In addition to reconstructing Holocene vegetational history, these paleoecological analyses permit climatic inducements of vegetation change to be inferred, and also allow speculation on the role of cove swamps as refugia during Holocene periods of climatic stress.

EFFECT OF WILD BOAR ON TREE GROWTH: AN ALTERNATIVE HYPOTHESIS

- - MICHAEL J. LACKI and RICHARD A. LANCIA, Departments of Forestry
and Zoology, North Carolina State University, Raleigh,
North Carolina

Recent investigations have indicated that rooting by exotic wild boar has depleted nutrient supplies in the litter layers and upper soil horizons of heavily impacted forest ecosystems. These nutrient losses are suspected to result in declines in the growth of the overstory plant species. Studies in high elevation beech gaps of the Great Smoky Mountains have produced conflicting results. Examinations of current years growth and past radial growth showed higher growth rates in trees of boar impacted gaps relative to control stands. Differences in correlations among stand chronologies also suggest boar impact to be significantly altering the growth regimes of these trees, especially on south-facing slopes. An alternative hypothesis predicting enhanced growth is proposed.

BLACK BEAR RESEARCH IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK, 1970-1982

- - MICHAEL R. PELTON, Professor, Department of Forestry, Wildlife, and Fisheries and Graduate Program in Ecology, University of Tennessee, Knoxville, Tennessee

Since 1971, over 70 publications and 29 theses/dissertations on 7 different species of mammals have resulted from research on wild mammals in the Great Smoky Mountains National Park (GSMNP). Approximately 50 projects have been completed or are presently being completed. These projects have been supported primarily by the University of Tennessee, Department of Forestry, Wildlife, and Fisheries through McIntire-Stennis and state funds, the Tennessee Wildlife Resources Agency, the Graduate Program in Ecology, U.T., and the Great Smoky Mountains Natural History Association. The National Park Service (NPS) has funded only 2 of the 50 projects, accounting for less than 5% of the budget.

Although much research has been conducted on other species such as European wild hogs, white-tailed deer, raccoons, and woodchucks, the major emphasis has been on black bears. To date, 18 theses/dissertations and over 50 publications have been completed on a wide variety of projects on this species; 9 additional projects are in varying stages of completion.

In 1968-70 the NPS was asking a number of questions about black bears in the Park. Some of these questions were judged critical by them for the future management of the species:

1) How many bears are there in the Park?

2) Is the population increasing, decreasing, or stable?

3) How can we (NPS) accurately and efficiently monitor year-to-year changes in the population?

4) Is GSMNP a refuge-sanctuary for bears supplying surpluses to Tennessee and North Carolina for hunting and to what extent does this occur?

5) What impact does the NPS have on the population when it removes or moves nuisance bears?

6) How can person-bear interactions be prevented?

7) What are the critical factors in the GSMNP which contribute to or detract from the well-being of black bears?

8) Incidental questions:

   a. Where and when do bears den?
   b. What do bears eat?
   c. What, where, and how much do they move?

With these questions in mind, field work was initiated in the summer of 1970. A primary thrust of the research has been to determine precise and accurate population density and indices. This has been accomplished through an intensive trapping and tagging program with concomitant evaluations of various potential indices. In 1970 no one had ever accurately censused a wild black bear population, much less developed an accurate population index. In fact, very little was known about the species; techniques for studying the animal were crude at best. During the 1970's the development of capture (snares), handling (wide tolerance drugs), and monitoring (radio telemetry) techniques for black bears emerged. Research efforts in the GSMNP were at the forefront of such efforts. With these better techniques animals could be captured and monitored more easily and accurately. Consequently, more recent studies have concentrated on natality-winter denning, mortality, and movement ecology since it is these 3 areas that interact and result in the population density of black bears. Natality is related to winter denning and has necessitated the radio-collaring and monitoring of adult females in dens to assess cub production, breeding periodicity, fecundity in general, and relations of cub production to various environmental factors such as mast yields. Mortality has been very difficult to assess due to the high percentage of animals killed illegally by poachers. However, in recent years we have accumulated data from radio-collared bears killed inside and out of GSMNP legally and illegally and are beginning to get a more accurate picture of this parameter. Movements have been monitored on nearly 100 bears in GSMNP and on adjacent national forests. We have documented general movements and activities, relation of movements to mast production, effects of roads on movements, home range dynamics by sex/age groups, territoriality, home range overlap, diel movements, fall shuffle, subadult dispersal, etc. Another major thrust of our efforts have dealt with person-bear interactions. We have completed some studies in frontcountry and are now concentrating our efforts in backcountry.

Other incidental but very important studies have included food habits, blood parameters, parasitic and infectious diseases, history, mark trees, and behavior.

Specific results of all the studies are available in the form of annual progress reports, theses/dissertations, and publications in the GSMNP library. The 1980 progress report summarizes all our publications to date (pp. 49-62) and is available in the Park library.

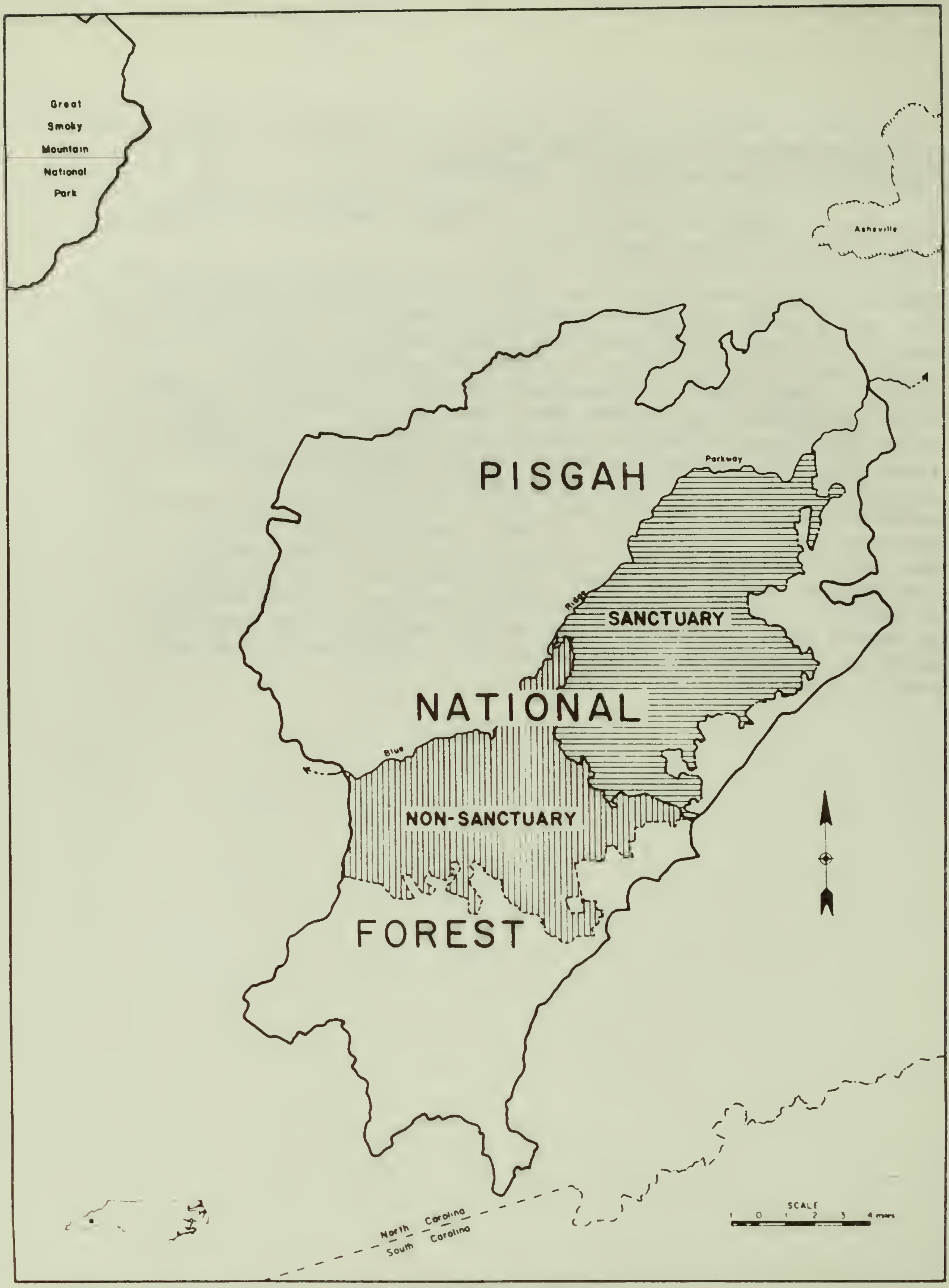
Future efforts will include the development of age-specific natality and mortality rates, simulation modeling, development and refinement of a computerized data system for retrieving specific parameters, nutrition studies, transplant-restocking evaluations, micro-habitat preference studies, testing new deterrent systems, physiological-behavioral winter denning efforts, and continuation of the population indices-environmental interaction studies.

I feel this has been and still is the most comprehensive research effort ever undertaken on black bears in North America; it could not have been accomplished without the tremendous support of various local NPS personnel in GSMNP. To them I continue to owe a great deal of gratitude. In addition, I would be remiss if I did not point out that this research program would not have been accomplished without supreme efforts and sacrifices on the part of the graduate students who carried out the research, persisting through long, hard hours in the field and lab, limited budgets, and many other trials and tribulations.

BLACK BEAR SANCTUARIES: PRELIMINARY EVALUATION AND POTENTIAL IMPACTS OF ADJACENT NATIONAL PARK SERVICE DEVELOPMENTS

- - GORDON S. WARBURTON, Department of Zoology, North Carolina State University, Raleigh, North Carolina

Black bear sanctuaries were created to protect a breeding nucleus of bears that produce a dispersing surplus of bears into the surrounding areas for harvest. Seven adult bears were radio collared and 7 juvenile bears were ear tagged on a sanctuary in western North Carolina to determine if the sanctuary was meeting its goals. Many of the preliminary results show good signs that sanctuaries may be providing an area for breeding nucleus establishment. The proximity of the study area to the Blue Ridge Parkway and the National Park Service developments on the Parkway facilitates study of the potential impacts of National Park Service activities on the adjacent bear sanctuary. The ranges of all bears radio collared in the sanctuary overlapped in the vicinity of the National Park Service developments. Some of the bears visited the campground facility habitually. Removal of reproductive females from the campground area may negate positive effects of the nearby sanctuary. The need for coordination between sanctuary management and management of adjacent areas is evident.



The Pisgah National Forest Black Bear Sanctuary.

DIURNAL AND NOCTURNAL MOVEMENTS OF BLACK BEARS IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK

- - PATRICK C. CARR, Department of Forestry, Wildlife, and Fisheries, University of Tennessee, Knoxville, Tennessee

Summer and fall diurnal and nocturnal movements of black bears (*Ursus americanus*) were compared for the years 1980 and 1981 in the Bunker Hill area of the Great Smoky Mountains National Park. Diurnal (0600-2000 hr) rates of travel were greater than nocturnal (2100-0500 hr) rates for both years and both seasons in the 2 years. Diurnal travel rates were greater than nocturnal rates among all sex and age classes. Males exhibited significantly greater diurnal travel rates than females (1.01 km/hr to .077 km/hr, $P < 0.02$) during the summer but showed no significant difference in the fall, although male rates were greater (1.31 km/hr to 1.11 km/hr). Females with cubs traveled at lesser diurnal and nocturnal rates than breeding or solitary adult females but these rates showed significance only during the fall (diurnal, 0.72 km/hr to 1.59 km/hr, $P < 0.001$; nocturnal, 0.26 km/hr to 0.48 km/hr, $P < 0.049$). Less rates of travel for females with cubs are probably due to the limited mobility of the cubs. Diurnal travel rates for all bears in fall 1980 were significantly greater than both summer 1980 rates (1.25 km/hr to 0.84 km/hr, $P < 0.004$) and fall 1981 rates (1.25 km/hr to 0.74 km/hr, $P < 0.009$). The above discrepancy is likely due to the poor year of mast production and subsequent lack of acorns as a food item in the study area in fall 1980. The greater diurnal movements represented a quest for food sources leading to an emigration out of the study area by 11 of 13 radio-collared bears during September and October, 1981.

ECOLOGY AND BEHAVIOR OF BACKCOUNTRY PROBLEM BEARS: A SUMMARY OF PROGRESS

- - BRUCE C. HASTINGS, Department of Forestry, Wildlife, and Fisheries and Graduate Program in Ecology, University of Tennessee, Knoxville, Tennessee

National parks in the United States and Canada have a long history of management problems with bears. Traditionally, the major problem has been found in frontcountry areas such as picnic grounds and along roadsides. However, through alterations in bear management in the frontcountry and a noticeable rise in bear damages in the backcountry, the major concern with bears in the Smokies may have changed to the backcountry.

Several research projects in national parks have attempted to document what happens when bears and people come together. In order to complete our understanding of the relationship between people and problem bears, we also need to document what these bears are doing when not interacting with campers.

The pilot work for this study was initiated during June 1981. Seven bears were captured. All were females except for 1 of 2 cubs that were sedated. Radiocollars were placed on 5 of the bears: 3 at Mt. LeConte, 1 at Spence Field, and 1 at Siler's Bald. Movement and activity data were collected through the use of groundtracking procedures during the summer, airtracking techniques during the autumn, and both methods during the spring.

Four of the five bears' dens were found during the winter and early spring. Two wintered in trees while two others stayed in ground dens. A fifth bear and her three yearlings were found eating beechnuts near Siler's Bald during March; it is uncertain whether this bear ever denned. One of the bears on Mt. LeConte removed her collar and left it in her ground den.

Presently, the movements and activities of the four radiocollared bears are being documented. Efforts are also being made to expand the study to Walnut Bottom and other appropriate sites. A goal of ten collared bears is being sought.

PRELIMINARY RESULTS OF BAIT-STATION SURVEYS TO MONITOR RELATIVE ABUNDANCE, DISTRIBUTION AND ACTIVITIES OF BLACK BEARS IN THE SOUTHERN APPALACHIAN REGION

- - KENNETH G. JOHNSON, Department of Forestry, Wildlife, and Fisheries, University of Tennessee, Knoxville, Tennessee

Visitation to bait-stations correlated ($r = 0.91$, $P < 0.03$) with Jolly-Seber population estimates (1973-1977) and visitation rates ($\bar{x} = 49.4\%$) were calibrated with the high bear densities (approximately 1 bear per 2.5 km^2) in the NW quadrant of the Great Smoky Mountains National Park. Bait-station surveys were expanded on an experimental basis to the Tellico district of the Cherokee National Forest in July 1980. In July 1981, the surveys were further expanded, and visitation rates for areas sampled were: Unicoi (11.8%), Greene (2.5%), and Cocke (12.5%) Counties of the North Cherokee Wildlife Management Area; the Harmon Den and 12-Mile Strip areas of the Pisgah National Forest, N.C. (11.7%); the GSMNP (park-wide, 34.0%); and the Tellico (17.0% in 1980, 22.1% in 1981) and Ocoee (2.9%) areas of the South Cherokee Wildlife Management Area. There was no difference ($P < 0.32$) in visitation rates between 1980-1981 in Tellico. Visitation was greater ($P < 0.005$) in the GSMNP than in other areas sampled. Within the GSMNP, visitation rates in 1981 ranged from 19.3% in the SE quadrant to 50.9% in the NW quadrant. Low population levels in the SE quadrant may be related to illegal hunting and trapping associated with the adjacent Cherokee Indian Reservation. Distributional and activity data from bait-station surveys are being evaluated in relation to habitat types, roads, access, remoteness, elevation, topography, designated bear sanctuaries, wilderness, seasonal changes, and land use patterns. These data will be analyzed in relation to baseline radio telemetry information accumulated for 10 years in the GSMNP, 5 years in Tellico, and 1 year in Pisgah. Black bears are sensitive environmental indicator species, and bait-station surveys provide a valid and feasible technique to monitor relative abundance, distribution, and activities in relation to land management policies.

HUMAN-BEAR INTERACTIONS IN THE BACKCOUNTRY OF GREAT SMOKY MOUNTAINS NATIONAL PARK

- - PAMELA A. PETKO-SEUS, Department of Forestry, Wildlife, and Fisheries, University of Tennessee, Knoxville, Tennessee

To manage potentially dangerous interactions between people and black bears, bear habits and behavior must be understood. Equally important is an understanding of the Park user. One of the major goals of this study is to reach a better understanding of backpackers, in the backcountry of Great Smoky Mountains National Park, through a survey of their attitudes and knowledge regarding black bears. A preliminary questionnaire was developed, pretested (in the backcountry), and revised during the summer of 1981. Park records (1979-1981) have been reviewed to determine the frequency of reported bear observations and incidents at various backcountry sites within the Park.

During the summer and fall of 1982, 200 backpackers will be personally interviewed through a 75-item questionnaire. The sample will be equally divided among shelter sites and campsites that have had high reported bear activity over the last three years, and those sites that have had little or no reported bear activity. A sample of 100-200 front country campers will be obtained for comparison. Preliminary responses indicate a lack of knowledge regarding black bears. For example, some backcountry users do not realize black bears can climb trees, or that they may be active during daylight hours. These misconceptions result in improper food storage. Before entering the backcountry, the user needs more information than he/she is currently receiving from the National Park Service. To compensate for the inherent bias in a questionnaire study, and to aid the NPS in making recommendations for minimizing black bear caused injury and property damage, observations of humans and bears interacting are being recorded and analyzed. The type of aggressive behavior demonstrated by people and/or bears seems to be very important to the outcome of a confrontation.

DENNING AND REPRODUCTION OF BLACK BEARS IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK (GSMNP) AND CHEROKEE NATIONAL FOREST (CNF)

- - GREG WATHEN, Department of Forestry, Wildlife, and Fisheries,
University of Tennessee, Knoxville, Tennessee

A study concerning the reproductive biology and denning ecology of black bears (Ursus americanus) in the GSMNP and CNF was continued during the summer of 1981 and winter of 1981-82. Black bears were trapped during the summer, and the reproductive status of females was determined. Selected females were fitted with radio transmitters for monitoring during the winter. Of 17 individual female black bears captured during the summer of 1981, only 1 (5.9%) was lactating. Six of 25 adult females visited in dens during the winter of 1980-81 were with newborn cubs.

Female black bears entered dens from 28 November 1981 to 8 January 1982 ($\bar{x}$ = 16 December 1981, n = 14), and emerged from before 10 March 1982 to 29 April 1982 ($\bar{x}$ = 7 April 1982, n = 19). Females with newborn cubs emerged from dens later ($\bar{x}$ = 24 March 1982, n = 2), although not significantly.

The dens of 29 female black bears were located and visited during the winter of 1981-82. Nineteen (65.5%) females denned on the ground with the remaining 10 (34.5%) denning in tree cavities above the ground. The majority of ground dens were rock crevices (n = 5), ground nests (n = 5), and cavities under root systems of overblown trees (n = 4). The majority of trees used as dens were chestnut oak (n = 4) and northern red oak (n = 2). Entrances to tree dens were 6.5 to 27.5 m ($\bar{x}$ = 13.9 m) above the ground. Compared to the winter of 1980-81 when 78.6% of female black bears denned in trees, there was a highly significant difference in den type preference during the winter of 1981-82 (X^2 = 11.88, $P < .005$).

Twenty-six of the 29 female black bears monitored during the winter of 1981-82 were adults; 23 of these 26 adults (88.5%) were with newborn cubs; 2 (7.7%) were with yearlings; and 1 was without offspring. The average litter size of newborn cubs was 2.53 and the sex ratio of males to females was 0.9:1. Litters of 2 and 3 were the most common (n = 15; 79.0%), but litters of 1 (n = 2; 10.5%) and 4 (n = 2; 10.5%) also occurred. Distinct chest blazes occurred on 3 of 37 (8.1%) cubs in winter dens, but the occurrence of a few white chest hairs was noted on 17 of 37 (45.9%).

The weights of 35 individual cubs were obtained from 26 February to 19 March 1982. One cub from a litter of one weighed 5.5 lbs. Cub weights averaged 4.75 lbs. (n = 8) for litters of 2, 4.17 lbs. (n = 18) for litters of 3, and 2.70 lbs. (n = 8) for litters of 4 ($P < .05$). The difference in weight between the smallest and largest cub within a litter was calculated for 12 litters. The average difference in weight for litters of 2 was 0.375 lbs. (n = 4), 0.479 lbs. for litters of 3 (n = 6), and 1.313 lbs. for litters of 4 (n = 2). The difference in weight was significantly smaller in litters of 2 than in litters of 4 ($P < .05$).

CHANGES IN AVIFAUNA WITH ELEVATION AND TOPOGRAPHY IN GREAT SMOKY MOUNTAINS NATIONAL PARK: RIDGETOPS vs. VALLEY SIDES

- - KENNETH N. BAKER, University of Pennsylvania

In the summer of 1982 I censused passerine birds at 6 evenly spaced elevations (800-1425 m) within the deciduous forests in each of 4 areas: along Forney and Thomas Ridges and along the valley sides to the west of each ridge. Censusing provided a 0-4 index of abundance for 28 relatively common species at each of the 24 census sites. Plots of species abundance-index values vs. elevation, ordinations comparing bird distributions in Forney and Thomas areas, and percent similarity comparisons of bird communities at similar elevations suggested that birds often display preferences for particular elevations and for ridge or valley forests. These preferences tended to be similar in the two ridge-valley systems. It is unclear whether birds select particular elevations or topography per se or if they are sensitive to differences in vegetation that develop over various sites.

COMPETITION BETWEEN TWO SPECIES OF DARTERS

- - LARRY A. GREENBERG, Department of Ecology and Systematics, Cornell University, Ithaca, New York

As part of a larger study which examines the relationship between interspecific competition and longitudinal succession, I investigated the competitive interactions between two species of darters, *Etheostoma simoterum* (Tennessee snubnose darter) and *E. rufilineatum* (redline darter) in the Little River of eastern Tennessee. These two species, which have the largest longitudinal distribution for darters in the Little River, show at least fourfold increases in density with decreasing elevation. Underwater censuses of transects revealed that *E. simoterum* is most abundant in runs, whereas *E. rufilineatum* is concentrated in riffles. A pilot experiment on the competitive interactions between *E. rufilineatum* indicated that *E. rufilineatum* restricted the spatial distribution of *E. simoterum*. *E. simoterum* was found along the stream's margins, whereas *E. rufilineatum* was found further away from shore. After the removal, *E. simoterum* moved further away from shore. When *E. rufilineatum* was added to the stream, *E. simoterum* was again found restricted to the stream's margins. Removal and addition experiments of *E. simoterum* and *E. rufilineatum* at several sites along the stream are planned for this summer.

INVERSION FREQUENCY DYNAMICS ALONG THE SMOKY MOUNTAINS CLINE IN *DROSOPHILA ROBUSTA*

- - W. J. ETGES, Department of Biology, University of Rochester,
Rochester, New York

Clinal changes in 12 paracentric chromosomal inversions occur along the altitudinal gradient from the 1000 ft. elevation (outside the park) to 4800 ft. along the West Prong of the Little Pigeon River in populations of the fruit fly, *Drosophila robusta*. The cline in inversion frequencies is manifest in all three chromosomes and has been assumed to be the product of the natural selection. These populations were sampled in 1946 and in 1959 by different workers, and again in the summer of 1981. Long term changes in inversion frequencies are apparent in the comparison of past with present collections and suggest a trend toward an overall shift to inversion frequencies characterizing the higher elevation populations. Of great interest is the cause for such evolutionary change whether caused by a change in environment or genetic alteration. Environmental change in the form of forest regrowth since logging around the turn of the century is a working hypothesis for the temporal shift in inversion frequency over the last 35 years in these populations.

SUMMARY OF TOPIC SESSION

ACID PRECIPITATION EFFECTS RESEARCH

- - HARVEY OLEM (Moderator), Tennessee Valley Authority, Chattanooga, Tennessee

To date, most investigations of the effects of acid deposition on natural resources have focused on glaciated regions in the northeastern United States, southeastern Canada, and northern Europe. Yet certain conditions known to exist in the southeastern United States--particularly the Southern Blue Ridge Province (SBRP) which includes the Great Smoky Mountains--indicate that this region, too, may be vulnerable to the effects of acid deposition. Because of the unique features of the SBRP region (e.g., manmade reservoirs rather than natural lakes, older soils, much less snowmelt and other climatic differences, and regional variations in atmospheric sources, transport, and deposition), reliance solely on the northern efforts could result in requirements for mitigation that might not be appropriate (cost-effective) or environmentally effective for this region.

Papers presented during this session describe research results or studies just underway which fit into a coordinated effort recently prepared by a group of federal, state, and private cooperators. The comprehensive plan, as described in the first paper of the session described research results related to aquatic resources (fishery losses described research results related to aquatic resources (fishery losses in hatcheries, water quality changes during fishkills, acute effects to rainbow trout, chemical interactions), as well as desposition monitoring (atmospheric deposition in the Tennessee Valley) and terrestrial studies (cation leaching in two deciduous forests, impacts to lichens, forest growth responses). These investigations complement national research efforts such as the National Acid Precipitation Assessments, the Electric Power Research Institute studies, and various private and state efforts.

ACIDIC DEPOSITION RESEARCH PLAN FOR THE SOUTHERN BLUE RIDGE PROVINCE

- - HARVEY OLEM, GEORGE J. HYFANTIS, JR., and RICHARD J. RUANE,
Tennessee Valley Authority, Knoxville, Tennessee

The Southern Blue Ridge Province is one of this country's more sensitive regions in regard to acid deposition. For this reason, a plan for a coordinated investigation of the impacts of acid deposition has been prepared by a group of cooperators. The basic objective of the research plan is to determine whether acid deposition is significantly impacting the fisheries resources of the Southern Blue Ridge Province. This comprehensive investigation is designed to complement national research efforts such as the National Acid Precipitation Assessment and the Electric Power Research Institute studies as well as various private and state efforts.

The proposed work will focus on fisheries impacts; however, a major portion will involve the determination of how acid deposition affects the quality of water. Sites representative of high-elevation watersheds and reservoirs will be selected for intensive study. Detailed monitoring will be conducted to determine atmospheric deposition, watershed soil and water chemistry, stream and reservoir water quality, and hydraulics and biota. Models will then be used to assess impacts at various levels of acid deposition in similar reservoirs and watersheds throughout the Southern Blue Ridge Province. Regional sources and pathways for acid deposition will be investigated and atmospheric transport models applied to evaluate the effectiveness of reducing emissions.

ATMOSPHERIC DEPOSITION IN THE TENNESSEE VALLEY: 1979 - 1980

- - WILLIAM J. PARKHURST, ROY V. CARTER, FRANCES P. WEATHERFORD,
and J. DALE ROBINSON, Tennessee Valley Authority,
Muscle Shoals, Alabama

Wet and dry atmospheric deposition data collected at 17 sampling sites across the Tennessee Valley provided the first comprehensive look at the "acid rain" phenomena in the south-central United States. Each biweekly sample was analyzed for pH, sulfate ($SO_4^{=}$), nitrate (NO_3^{-}), phosphate ($PO_4^{\equiv}$), fluoride (F-), chloride (Cl-), ammonium (NH_4^{+}), potassium (K+), sodium (Na)+, calcium (Ca++), and magnesium (Mg++). Data distributions, by constituent and site, revealed that the wet deposition of H+, $SO_4^{=}$, NO_3^{-}, and Ca++ is relatively uniform throughout the Valley. The remaining wet constituents, and all dry constituents were highly variable from site-to-site. Data collected from those sites nearby TVA's coal-fired power plants did not differ significantly from those collected at remote rural sites. Between site correlations are generally higher for wet deposition than for dry. For wet deposition, the percentage of site pairs showing significant ($\alpha = .05$) correlations was inversely proportional to the distance between sites. This relationship did not hold for dry deposition. The median total deposition values (kg/ha) were 39 ($SO_4^{=}$), 17 (NO_3^{-}), 0.8 ($PO_4^{\equiv}$), 0.5 (F-), (Cl-), 0.7 (H+), 2 (NH_4^{+}), 2 (K+), 3 (Na+), 7 (Ca++), and 0.7 (Mg++) with dry deposition accounting for 12 to 15 percent of the total for $SO_4^{=}$, NO_3^{-}, F-, Cl-, NH_4^{+}, and Na+ and 25 to 36 percent of the total for $PO_4^{=}$, K+, Ca++, and Mg++. Annual deposition isopleths for H+, $SO_4^{=}$, and NO_3^{-} do not reveal regional gradients. However, concentration isopleths do suggest north-south gradients with higher concentrations in the north.

SURVEY OF FISHERY LOSSES IN HATCHERIES NEAR THE GREAT SMOKY MOUNTAINS NATIONAL PARK AND RELATION TO ACID PRECIPITATION

- - CRAIG PHILLIPS and RAYMOND C. MATHEWS, JR., National Park Service, Uplands Field Research Laboratory, Great Smoky Mountains National Park, Gatlinburg, Tennessee

Our survey contains information gained from 25 trout hatcheries close to the perimeter of Great Smoky Mountains National Park (GRSM) related to fish kills between 1979 and 1981. Acid precipitation surfaced as a major suspect of cause, since many of these fish kills were associated with stream pH depressions and elevated heavy metal concentrations that typify acid-precipitation-related effects in other parts of the country where fishery resources have been impacted. The loss of fishery resources in the southeastern United States as a probable consequence of acid precipitation has not been documented, as far as is known, though the depression of precipitation pH and its chemical/physical effect on streams in the acid sensitive terrain of the Southern Appalachians has been a factor of concern for several years. Our attention was first drawn to the loss of 1,000 adult Rainbow trout (*Salmo gairdneri*) in the Cherokee Hatchery (North Carolina) bordering GRSM and receiving its water source from Raven Fork Creek draining from the park. Our survey quickly revealed that this was not an isolated case and that such fishery losses had occurred before the Cherokee incident. Such losses were not reported before the latter part of 1979 and thus pose a relatively new problem for this area. Only rainbow trout mortalities have been documented, although brook (*Salvelinus fontinalis*) and brown *Salmo trutta*) trout were exposed to the same waters in the Cherokee Hatchery, and no mortalities have been observed outside hatcheries waters.

A total of 104,102 fingerling (1"-5") and 100,917 adult (6"-20") rainbow trout mortalities were documented by this investigation, which represents a sizeable proportion of those fisheries, and undoubtedly more fish would have died if mitigative measures (such as use of lime) had not been implemented. Several fish mortalities occurred during dry weather/low flow conditions, in which there were a smaller number of mortalities among rainbow trout fingerlings, though greater number among adults. Although singular incidents of fish kills have occurred at numerous area hatcheries, only hatcheries located on Raven Fork Creek have suffered multiple fish kills (Cherokee - 2, Blankship - 5) following precipitation. Increased acidity alone is probably not the only toxic factor involved in these fishery losses, and elevated aluminum concentrations seem to characterize several of these affected waters associated with heavy rains. Most of the hatcheries in this area now control fishery losses by use of lime whenever storm activity commences and fish begin showing signs of stress. A concern that follows these findings is our capability to deter fishery losses in natural streams if circumstances become severe enough to cause mortality there and if sublethal stresses are already impacting fish and other aquatic life.

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INCIDENCE OF SPINAL DEFORMITIES IN SMALLMOUTH BASS FROM LAKE CHATUGE - A PROGRESS REPORT

- - MICHAEL J. VAN DEN AVYLE, U. S. Fish and Wildlife Service, Georgia Cooperative Fishery Research Unit, University of Georgia, Athens, Georgia

Angler reports of deformed smallmouth bass (Micropterus dolomieui) in Lake Chatuge, Georgia and North Carolina, have increased in frequency since 1978 and some fishermen now claim that the incidence is as high as 33% for fish they catch. There has been speculation that the deformities may be caused by acidification of the system, and although Lake Chatuge is very poorly buffered and likely is susceptible to acid inputs, no evidence presently exists to directly link deformities with acidification. Initial efforts to determine the cause(s) of the deformities have addressed the need for a better understanding of their nature and incidence. The Georgia Department of Natural Resources (Game and Fish Division), Tennessee Valley Authority, and Georgia Cooperative Fishery Research Unit have collaborated in field sampling and the Unit has been responsible for examination of the fish.

A total of 196 smallmouth bass ranging 52 and 360 mm total length was obtained during six electrofishing sample trips between July 1981 and May 1982. Of these, 117 have been x-rayed, and 13 fish (11.1%) were deformed. Deformities of the vertebral column included lordosis, scoliosis, kyphosis, and combinations of these. The incidence of deformities varied with fish size. The smallest deformed specimen was 138 mm, the largest was 300 mm, and the percentages of deformed fish for 50-mm size classes were (n = no. examined): 51-100 mm = -% (n = 20); 101-150 mm = 2% (n = 40); 151-200 mm = 22% (n = 18); 201-250 mm = 21% (n = 29); 251-300 mm = 25% (n = 8); 301-350 mm = 0% (n = 1); 351-400 mm 0% (n = 1).

The incidence of deformities in fish caught by anglers has been monitored by Georgia DNR since February 1982. A total of 147 fish was measured and visually examined for deformities as of June 9, 1982, and 20 (13.6%) were deformed. The percentages by size groups were: 151-200 mm = 0% (n = 1); 201-250 mm = 40% (n = 5); 251-300 mm = 27% (n = 22); 301-350 mm = 23% (n = 35); 351-400 mm = 7% (n = 55); > 400 = 0% (n = 29).

Comparison of the two sets of data generally is not possible because electrofishing provided smaller fish than those observed by the creel clerk. It is clear, however, that the detected incidence of deformities changes with fish size and is highest for fish between 200 and 350 mm long. Additional work is needed to determine if these variations of incidence are related to the timing of some environmental stress or are related to poor detectability of deformities in small fish or reduced survival of deformed individuals (which would lead to decreased incidence with size).

WATER QUALITY CHANGES DURING FISHKILLS IN AN ACID-SENSITIVE WATERSHED, CHEROKEE, NORTH CAROLINA

- - LISA M. BEARD and HARVEY OLEM, Tennessee Valley Authority,
Norris, Tennessee

The possible causes of fishkills in trout-rearing operations in the Raven Fork Watershed were investigated. The nature of water quality changes during storm events and the possible factors affecting water quality were evaluated in an attempt to better understand the relationship between the fishkills and environmental factors.

Automatic streamwater samplers and continuous instream monitors provided information on chemical characteristics during both baseflow and stormflow conditions. Measurements of pH, temperature, dissolved oxygen, conductivity, acidity, alkalinity, major cations and anions, and selected metals, including aluminum species, were obtained from streamwater just upstream from the trout-rearing operations and at selected locations in the headwater streams. During storm events instream pH was found to decrease as much as two units (from pH 6 to pH 4) and metals, particularly aluminum, were found to increase (from < 0.1 mg/L to almost 3 mg/L).

Based on these preliminary studies, certain factors which may be contributing to the fish mortalities are being investigated more closely, such as the contribution to stream acidity by naturally occurring organic acids and by acidic precipitation and the low neutralization capacity of area soils.

EFFECTS OF ACID PRECIPITATION ON CATION LEACHING IN TWO DECIDUOUS FORESTS IN EASTERN TENNESSEE[1]

- - D. D. RICHTER, D. W. JOHNSON, and D. E. TODD, Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee

To evaluate effects of acid precipitation on cation leaching processes in two forest ecosystems in the Valley and Ridge Province of Tennessee, solutions of bulk precipitation, throughfall, and forest soil leachages were collected throughout the 1981 water year and analyzed for major ionic constituents. Forest soil and nutrient cycling data were also assembled to examine the importance of atmospheric H^+-ion inputs to soil cation reserves in these base-poor, acid Udults.

In the 1981 water year, bulk precipitation was primarily a solution of dilute H_2SO_4 and SO_4^{2-} dominated anionic constituents in throughfall and soil leachates. Volume-weighted mean annual pH of bulk precipitation was about 4.3, of throughfall about 4.7, and of leachates from O_2, A_1, and B_{21} soil horizons about 6.0. At both sites base cations that exchanged with H^+-ions in acid precipitation were almost entirely supplied by forest canopies and litter layers and did not originate directly from exchangeable mineral soil pools.

The loss of H^+-ions from solution as rainfall passed through forest canopies (0.6 keq/ha in precipitation to 0.2 keq/ha in throughfall) amounted to about 10% of total base cations in the foliar canopies. The annual flux to the forest floor of the remaining 0.2 keq/ha of H^+-ions was equal to about 7% of the base cations in annual litterfall. Thus, atmospheric depositions of strong acids appeared to be readily reduced prior to rainwater's infiltration into mineral soils.

Mineral soil exchangeable bases, even in these base-poor Udults, were more than two orders of magnitude greater than annual H^+-ion input in bulk precipitation, and therefore represented a substantial reserve for the base cations in canopies and litter layers that exchanged with H^+-ions in acid rain. Annual fluxes of HCO_3^- alkalinity from B_{21} horizons, about 0.42 and 0.51 keq/ha at two sites, indicated that the natural H^+-ion input from the ionization of H_2CO_3 was of similar magnitude to H^+-ion input in acid precipitation in 1981. In the forest soil with large accumulations of hydrous Fe oxides (Fullerton series), hydrologic fluxes of SO_4^{2-} and base cations were reduced by about 50% between A_1 and B_{21} horizons, at least partly a consequence of SO_4^{2-} absorption by subsoils. In the forest soil with low contents of hydrous oxides (Tarklin series), fluxes of SO_4^{2-} and cations were not reduced with soil depth.

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[1] Supported jointly by the Electric Power Research Institute (RP-1813-1), the National Science Foundations's Ecosystem Studies Program (DEB-7824395), and the Office of Health and Environmental Research, U.S. Department of Energy, under contract W-7405-eng-26 with Union Carbide Corporation.

Based on 1981 data, H^+-ions in acid precipitation, 0.60 keq/ha, were equivalent to about 20% of the total cation flux from Tarklin subsoils. If all H^+-ions exchanged for base cations, strong acids in acid precipitation would appear to account for about 25% of the net cation removal (difference between base cation flux from subsoils and in bulk precipitation) from the Tarklin ecosystem.

Inputs of H^+-ions from acid precipitation represented on the order of about 0.4% of the base cations that are biologically cycling and immediately available in these ecosystems. The present magnitude of H^+-ion inputs indicates that cation leaching remains a process affecting cation reserves and soil development only over the long-term. Whether these increases in cation leaching rates will eventually have an adverse effect on cation reserves depends in large part on weathering rates and cation uptake by deep rooting, processes which at this time can not be reliably quantified.

CHEMICAL INTERACTIONS OF ACID DEPOSITION IN A SOUTH CAROLINA PIEDMONT WATERSHED

- - ALAN W. ELZERMAN, Environmental Systems Engineering, Clemson University, Clemson, South Carolina

This investigation started in mid-1980 and aims to obtain initial chemical information requisite to answering questions about the significance of acid deposition in the Piedmont and mountain regions of South Carolina, North Carolina, and Georgia. Atmospheric inputs of acidity and microcontaminants, interactions of atmospheric inputs with soils and water systems of the region, and fluxes of microcontaminants and nutrients through watershed systems as affected by acid deposition are all being considered with attention to potential impacts on biological resources.

A number of specific areas are being addressed to contribute to the overall objective, including the following:

(1) Neutralization mechanisms, rates and capacities in a representative watershed including rain-soil chemical interactions.
(2) Influence of acid inputs on fluxes of heavy metals and nutrients through watersheds.
(3) Transitory phenomena and changes in stream chemistry and surface waters associated with storm events.
(4) Analysis of historical trends and current atmospheric inputs by collecting data from other sources, including the National Atmospheric Deposition Program station operated by the Department of Agronomy and Soils, Clemson University.
(5) Kinetic studies of the rate and controlling factors of release of acidity and other materials from aerosols impacted on rain drops and lake surfaces.
(6) Ion exchange and metal-organic binding mechanisms, especially in relation to aluminum mobilization and acid neutralization.
(7) Relationship between acid inputs and mercury concentrations in water, sediments, and fish of regional reservoirs.

Alkalinity and pH surveys of lakes and reservoirs in the region have also been conducted to locate systems for future studies.

ACID RAIN AND GASEOUS POLLUTANT EFFECTS ON LICHENS*

- - LORENE L. SIGAL, Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee

Knowledge of the effects of the different air pollutants on lichens varies; more is known about sulfur dioxide (SO_2) than photochemical oxidants, such as ozone (O_3). Published information of the effects of pollutant interactions on lichens is sparse, and no information exists on the direct effects of wet acidic deposition. On-going laboratory research with lichens at Oak Ridge National Laboratory is focused on the latter two areas. With increased industrial growth and dependence on coal, the Southeast can expect greater air pollution stress on the environment. Lichens are good bioindicators of such stress.

To establish a threshold dose for individual and combined exposures of air pollutants, a series of laboratory experiments with SO_2 (at 306, 665, and 1064 g/m^3), O_3 (at 60, 120, and 240 g/m^3), $SO_2 = O_3$, and simulated acid rain (pH 2.3, 3.0, 3.3, 4.0, 4.3, and 5.6) is in progress. The preliminary data suggest that: 1) lichens are differentially sensitive to pollutants; 2) annual average levels of rainfall acidity (about pH 4.2) are probably not affecting the experimental lichens, but that Umbilicaria mannulata may be a good indicator of periodic low pH rainfall; 3) SO_2 alone, at low concentrations, is probably not very injurious to lichens; 4) O_3, at low concentrations, is injurious to lichens; and 5) SO_2 may have an ameliorating effect on the potential injury of lichens by O_3.

A field study of lichens in relation to air pollution in the Great Smoky Mountain National Park is planned with the object of documenting the distribution, abundance, and frequency of the dominant fructose and foliose lichens on conifers in the spruce-fir zone. The present condition of the lichens will be compared to historical collections in order to assess the species richness and vitality of the existing lichen communities. Permanent sampling sites will be established. Lichen species available for future proposed fumigation studies will be selected. The results of the field and laboratory studies will determine the susceptibility of the dominant lichens in the spruce-fir zone to SO_2, O_3, and SO_2+O_3, and acidic deposition, and identify the best lichen bioindicators in the Park.

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*Research sponsored jointly by the National Park Service, U.S. Department of the Interior under Interagency Agreement (pending) and the U.S. Department of Energy (under contract W-7405-eng-26 with Union Carbide Corporation).

ANALYSIS OF FOREST GROWTH RESPONSES TO AIR POLLUTION STRESS IN THE GREAT SMOKY MOUNTAINS, BUFFALO RIVER, AND ACADIA NATIONAL PARKS*

- - S. B. McLAUGHLIN and L. DITTRICK, Environmental Sciences Division,
Oak Ridge National Laboratory, Oak Ridge, Tennessee

The extensively-forested eastern U.S. has been subjected to elevated levels of air pollutants for several decades as regional-scale industrialization and urbanization have occurred. At present the effects of these pollutants, including both gaseous pollutants and acid rainfall, on regional forest growth have not been quantified. Important questions to be asked as future energy technologies and use patterns are planned for the region are: (1) What changes in plant productivity have occurred in the past as pollutant concentrations have reached phytotoxic levels; (2) What conditions have contributed most markedly to these changes; (3) What is the areal extent of these changes; and (4) What trends might be expected in response to future pollutant regimes. While we presently have extensive data on concentrations of the primary pollutants, SO_2, O_3, and NO_x required to cause visible injury to plant foliage, we know much less about effects on plant growth and yield under the chronic exposure regimes involving both gaseous pollutants and acid rain which presently occur over much of the eastern U.S. Such effects can be expected to be subtle and chronic and may result in altered dynamics of forest community growth and development, particularly in complex eastern deciduous forests. They can also be expected to be strongly influenced by both site variables such as soil chemistry and stand developmental stage and climatic factors such as temperature and rainfall. The FORAST (Forest Responses to Anthropogenic Stress) study is a recently initiated project designed to quantify long-term changes in forest growth and determine the association of these changes in both time and space with indices of stress from gaseous pollutants (primarily O_3) and acid rainfall. It is a broadly collaborative project presently involving twelve research sites utilizing a common research plan. Multivariate statistical analysis of annual growth trends will be used to quantify primary influences on annual growth as measured from increment cores. This is planned as a two-year project which focuses on development of methods to systematically examine regional growth patterns, determine if changes are occurring which can be correlated with acid rainfall and associated anthropogenic stress, and identify both the need and the methodology for further more intensive analysis. As a part of this study, sample plots are being established in the Great Smoky Mountains, Acadia (Maine), and Buffalo River (Arkansas) National Parks. These plots will provide a basis for evaluating responses of tree species in the parks as well as estimating the variability of response attributable to both geographical location and forest type.

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SUMMARY OF TOPIC SESSION

AIR QUALITY RESEARCH IN THE SOUTHERN APPALACHIAN MOUNTAINS

- - RAYMOND C. MATHEWS, JR., (Moderator), National Park Service, Uplands Field Research Laboratory, Great Smoky Mountains National Park

The preservation of natural ecosystems such as the Great Smoky Mountains National Park and Blue Ridge Parkway have not eliminated environmental threats associated with air quality degradation. The importance and magnitude of air pollution effects documented in the Southern Appalachian Mountains was reflected in last year's topic session, Air Pollution Monitoring and Effects Studies in the Southern Appalachians, moderated by John Skelly. This year's session indicates our attempt to coordinate research efforts which combine various facets of the numerous studies already in progress.

Using the Great Smoky Mountains National Park studies as a pilot program for pollutant monitoring in Biosphere Reserves (MAB), certain trace elements in vegetation and litter were found in high concentrations. In order to better document this and assess a wider spectrum of air pollutant accumulation in terrestrial ecosystems, repetitive field collections have been conducted with various laboratories analyzing subsamples for quality assurance. The results are inconclusive at this time but are still very evident problems. In addition, the NPS is funding a series of air quality projects through Oak Ridge National Laboratory to specifically investigate the question of high concentrations of lead and fluoride in vegetation and soils of the Great Smoky Mountains National Park.

The Tennessee Valley Authority Look Rock Air Quality Station received funding from the National Park Service this year for continued monitoring studies. Visibility degradation and elevated ozone levels have been identified as problem areas. The Tennessee Air Pollution Control Division has established a criteria pollutant monitoring station at the Elkmont area of the park. The effects of air pollution on air quality related values (AQRVs) continues to be investigated through selected tree species sensitive to SO_2 and O_3, lichens on high elevation spruce-fir forest, and some fish and salamander populations.

Fog interception has surfaced as an area needing expanded research efforts due to enhanced precipitation at high elevations through moisture scavenging by forest systems as frequent cloud masses pass through. Preliminary evidence indicates that park high terrains may be one of the moistest areas in the world as a result of such cloud moisture scavenging. Air mass trajectory characteristics continue to enhance source areas of air pollutants, but much more effort is needed in this and related research areas in order to fingerprint specific pollutant sources.

In conclusion, an integrated and comprehensive air quality research and monitoring program is evolving in the Southern Appalachians. We need to continue our monitoring efforts and further identify quantitatively the effects of air pollutants on living ecosystems while identifying specific AQRVs as appropriate to Clean Air Act legislation designed to prevent significant deterioration (PSD) of air in Class 1 areas.

PRELIMINARY EVALUATION OF TRACE ELEMENTS IN SAMPLES FROM THE GREAT SMOKY MOUNTAINS BIOSPHERE RESERVE

- - R. P. BRECKENRIDGE and G. B. WIERSMA, EG&G Idaho, Inc.,
Idaho Falls, Idaho

This study was conducted to evaluate the presence of selected trace elements that are being contributed by human activities to the Great Smoky Mountains Biosphere Reserve. Sampling was conducted at two remote sites within the Park. Preliminary results are reported for 11 elements present in vegetation (moss (several species)), witch hobble (Viburnum alnifolium), litter, and soil. In general, the relative levels of trace elements are highest in moss, followed by litter, witch hobble and soil. Levels of most of the elements reported have increased from values recorded in the 1978 to 1981 study.

ELEVATED OZONE LEVELS IN THE GREAT SMOKY MOUNTAINS DURING THE SUMMER OF 1980

- - R. J. VALENTE and R. E. CLARK, Tennessee Valley Authority,
Muscle Shoals, Alabama

During the summer of 1980, 1-hour average ozone levels in excess of 120 ppb occurred on at least ten days at the Look Rock research station located at the western edge of the Great Smoky Mountains National Park, the largest Class I PSD area in the eastern United States.

The meteorological conditions during the summer of 1980 were especially conductive to the formation and buildup of photochemical oxidants. Record heat, prolonged cloudless periods, and frequent stagnation episodes contributed to the potential for ozone production over the Southeast. In addition, the channeling and trapping effects of the Tennessee River Valley and the Great Smoky Mountains aggravated the poor dispersion characteristics during the episodes noted at Look Rock.

The accuracy of trajectory estimates is questionable under light wind conditions, especially in complex terrain areas such as the Great Smoky Mountains. Nevertheless, trajectories are useful in characterizing regional flow during the episode periods. Trajectory estimates, derived from the National Weather Service Boundary Layer Model, indicated short 48-hour back trajectories during the episodes, confirming the stagnant nature of the flow during these periods. Winds from the west dominated the period.

Look Rock ozone measurements differed in several respects from those made at other monitoring stations in the region. For example, the 24-hour average levels at Look Rock were often twice as high as those at other stations in the region. This difference resulted from high nighttime ozone levels at Look Rock in contrast to near zero levels at the other ground-based stations. This occurrence is not surprising considering Look Rock's elevation. Air sampled at night at valley stations is below the nocturnal inversion and is depleted of ozone through reactions with surfaces and nitric oxide. However, air sampled at night at mountaintop stations such as Look Rock is above the nocturnal inversion and is thus subject to less ozone depletion. Another difference between ozone at Look Rock and the other stations in the region concerned the minima and maxima of the diurnal cycles. Rather than reaching a minimum near sunrise as did the other stations, Look Rock ozone reached a minimum between 0900 and 1100 EST on the episode days. A factor which probably contributes to this effect is the breakup of the nocturnal inversion. The time of the Look Rock minimum is near the time of the breakup of the nocturnal inversion, suggesting that the Look Rock ozone minimum occurs concurrently with upward mixing of ozone depleted air which has been trapped in the radiation inversion layer the previous night. Furthermore, the Look Rock ozone maximum during the episodes occurred near 1800 EST rather than in early afternoon as those at the other stations, which suggests that transport played a role in the Look Rock daily maximum.

Although ozone levels in excess of 120 ppb occurred at Look Rock during the summer of 1980, none were recorded during the following summer. Comparison of these two years illustrates the elevated nature of the 1980 measurements, but only long-term monitoring can establish with certainty the frequency of recurrence of ozone levels similar to those recorded during the summer of 1980.

SURVEY OF LEAD IN VEGETATION AND SOILS OF THE GREAT SMOKY MOUNTAINS NATIONAL PARK[1]

- - RALPH R. TURNER, Environmental Sciences Division, Oak Ridge National Laboratory[2], Oak Ridge, Tennessee

Forest litter in the Great Smoky Mountains National Park (GSMNP), especially that from the highest elevations, is reported to have high concentrations of lead (up to 879 µg/g). Because underlying soils and understory vegetation contain relatively low levels, the source of the high lead in litter is hypothesized to be anthropogenic, deriving from long-range atmospheric transport and deposition on overstory foliage. This finding is quite consistent with findings elsewhere but the levels of lead contamination in litter are among the highest observed in forested areas and are similar to those in urban soils.

Research to be conducted by ORNL will confirm the high litter values for lead and address additional questions related to its biogeochemistry in the GSMNP. These questions pertain to (1) differences in Pb contamination between overstory hardwood and coniferous foliage, (2) spatial trends in foliage contamination, (3) evidence of foliar and root uptake, (4) possible historical record of contamination in tree rings, (5) litter contamination as a function of degree of decomposition, and (6) soil contamination as a function of depth. The results will improve our understanding of the extent of lead contamination in the GSMNP and, hopefully, provide some indication of temporal trends.

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[1] Research to be sponsored under Interagency Agreement DOE 40-1249-82 between the U.S. Department of the Interior, National Park Service and the U.S. Department of Energy.

[2] Operated by Union Carbide under contract W-7405-eng-26 with the U.S. Department of Energy.

FLUORIDE SURVEY OF VEGETATION AND SOILS OF THE CADES COVE AREA, GREAT SMOKY MOUNTAINS NATIONAL PARK*

--F.G. TAYLOR and P.D. PARR, Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee

Fluoride, the most phytotoxic gas among major air pollutants, is a cumulative toxicant with uptake occurring from foliar deposition of both gaseous and particulate fluorides. Because conifers retain metabolically active foliage for more than one growing season, analyses of foliage of different age classes can provide an indication of past and present air quality. Serveral species of pines were inventoried as long-term fluoride accumulators in the vicinity of a fluoride emitting facility near Oak Ridge. Results of that inventory suggested an investigation of vegetation in a more pristine area (Great Smoky Mountains National Park (GSMNP) to assess background concentrations. In January of 1980, foliage from four coniferous species in the Cades Cove area was collected, segregated according to age class (year of initiation), and analyzed for fluoride. Results of that study indicated that foliar fluoride concentrations in Cades Cove were greater than those in comparable age foliage among controls in the Oak Ridge area. Even though the elevated concentrations were less than the threshold for visible injury, there is a need to determine whether the elevated foliage concentrations may contribute to future impacts of air pollution in the flora of the park. This will be accomplished by determining fluoride concentrations among coniferous species and soils along a gradient of three elevations (cove, mid-mountain, mountain top) during two seasons (mid-growing season and post-growing season).

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*Research sponsored jointly by the National Park Service, U.S. Department of Interior under Interagency Agreement (pending) and the Office of Health and Environmental Research, U.S. Department of Energy under contract W-7405-eng-26 with Union Carbide Corporation.

FOG INTERCEPTION ON HIGH ELEVATIONS OF THE BLUE RIDGE PARKWAY IN NORTH CAROLINA

- - GARRETT A. SMATHERS, National Park Service, Cooperative Park
Studies Unit, Western Carolina University, Cullowhee,
North Carolina

Fog interception was determined for four southern Appalachian summit areas of North Carolina in the spruce/fir zone (1610-1855 m). Fog yield (mm) was determined as difference in precipitation received by paired Hellman rain gauges, one fitted with a Grunow fog intercepter. Fog yield was then computed as percentage gain over the rainfall received.

Gains in 1979 ranged from 51% at 1610 m to 94% at 1855 m. In 1980, a drought, which affected the entire eastern United States, started at the stations at 1610 m in June. All stations maintained relatively high gains ranging from 38% at 1610 m to 80% at 1855 m.

Notwithstanding drought stress, all stations reported gains that are among the highest reported for similar studies done of cloud forests in the United States and Mexico.

The question has arisen as to what is the relationship of fog interception to acid rainfall that prevails throughout the study area. The potential of trees and shrubs to intercept large quantities of fog and thus concentrate the acid precipitant in certain localities is discussed.

AIR MASS TRAJECTORY CHARACTERISTICS INFLUENCING GREAT SMOKY MOUNTAINS NATIONAL PARK

- - GRANT GOODGE, National Oceanic and Atmospheric Administration, National Climatic Center, Asheville, North Carolina

RAYMOND C. MATHEWS, Jr., National Park Service, Uplands Field Research Laboratory, Great Smoky Mountains National Park, Gatlinburg, Tennessee

Using the Hefter Transport Model, we have now run airmass trajectories for all precipitation events that occurred in the Great Smoky Mountains National Park from July 1, 1979, to June 30, 1980. By grouping these trajectories into 16 corridors, it was possible to quantify them into a more usable data set.

On an annual basis, it was found that the majority of these trajectories were entering the park from the south-southeast through a westerly direction. The corridor with the highest frequency was from the south. However, when the trajectories were broken down by season, some variations were detected. Beginning with the spring season, we found higher percentages in the south-southwest through westerly directions which reflect the circulation patterns associated with the stronger low-pressure systems that moved to the northwest of the park and kept it in a more southwesterly flow.

The summer season showed a wider scattering of trajectories due to a lack of a consistent pattern of flow; however, the percentages were still at a maximum in the southeast through westerly direction. During the late summer, trajectories tended to become more easterly to southeasterly due to the intensification of the "Bermuda High" pressure system.

The fall season tended to reflect some of the same features of late summer, with percentages from the south-southeast and southeast being considerably higher than for the same corridors on an annual basis. Much of this increase was due to several tropical storms that moved up the east coast and circulated moisture into the park from a more easterly direction. Wintertime trajectories showed a wider variance in trajectory paths, with the most significant increase occurring in the northwest corridor. This was because several precipitation events continued after the wind had shifted to the northwest behind the cold fronts. Despite the higher percentage of northwest trajectories during the winter, the predominant directions were still south through southwest.

SUMMARY OF TOPIC SESSION

WATER QUALITY RESEARCH IN THE SOUTHERN APPALACHIAN MOUNTAINS

- - RAYMOND C. MATHEWS, JR., (Session Chairman), National Park Service, Uplands Field Research Laboratory, Great Smoky Mountains National Park

A great diversity of research interests were evidenced by this year's series of presentations in the area of water quality. The use of established experimental stream monitoring sites in the Great Smoky Mountains National Park (GRSM) has been made available to many researchers over the last three years. A primary productivity study on phytolithic communities is now nearing completion in those streams. Our own experimental stream monitoring program is expected to evolve into a more intensive study of only one virgin forest watershed. Recommendations are solicited which might help produce the best possible stream monitoring/research program in view of available resources for the GRSM. The long term problem of Anakeesta leachate influences on park streams is still a focus of much concern in the GRSM and surrounding area with similar pyritic bedrock exposures. Legionnaire's Disease bacteria joins the list of new and exotic inhabitants of supposedly pristine park stream waters. These natural populations do not, apparently, represent a health-related problem under these conditions at present densities in the GRSM, according to Oak Ridge National Laboratory researchers, but its occurrence certainly represents a biotic benchmark for our area. Other research by Oak Ridge National Laboratory in the park is oriented toward flow and temperature relationships and their effects on biotic use in streams as a baseline resource investigation. The effect of precipitation on the seasonal dynamics of macroinvertebrate communities in the Balsam Mountains represents one of only a few studies in this area on macroinvertebrate populations. The Southern Appalachian Mountains are characterized by rich diversity of benthic organisms, and research on this area deserves further attention.

Although studies on trout populations have been greatly reduced in the GRSM, and native Brook trout recovery programs utilizing the Young Adult Conservation Corps through a special U.S. Fish and Wildlife Service program is no longer viable, trout population studies continue in Cumberland Gap National Historical Park and low-elevation big waters of the GRSM through efforts of the U.S. Fish and Wildlife Service, Cherokee Office. A study of heavy metals in the tissues of Rainbow trout was funded by the National Park Service to the University of Georgia, and that program is nearing completion. Recent attention has been focused on Big South Fork National River and Recreation Area as potential for a recreational fishery, though a number of perturbations, including surrounding strip mine activity, affect the watershed.

One of our greatest needs in the area of water quality for this region is baseline historical data, which is not readily available and makes interpreting present conditions difficult. An area of special need, therefore, would appear to be indications of past and present water quality conditions so that trend analyses can be facilitated. Our research efforts in water quality studies are varied and exploratory, generally without long-term objectives, and thus an apparent need exists to more cohesively tie together our research efforts in this field.

PRIMARY PRODUCTIVITY OF THE PHYTOLITHIC COMMUNITIES IN STREAMS IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK

- - ELAINE D. KEITHAN, Bowling Green State University, Bowling Green, Ohio

An incubation chamber for _in situ_ measurements of ^{14}C uptake was used to determine primary production rates of phytolithic communities associated with major different habitats found in lotic systems. Phytolithic (phytolithon) is a term suggested to describe the component of epilithic communities utilizing photosynthesis in the production of organic matter. The studies are being carried out over a one year period in the Great Smoky Mountains National Park using two streams as the experimental sites: Husky Branch and Camel Hump. Preliminary findings are presented on the productivity associated with different physical and chemical parameters in each habitat. Measurements of carbon assimilation were significantly greater in habitats of higher current velocity and light availability. Correlations are being made between productivity and other measured parameters in this study. These correlations may indicate the importance of physical and chemical parameters in relation to each other, phytolithic productivity and biomass.

SURVEY OF STREAMS IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK FOR LEGIONNAIRES' DISEASE BACTERIA[1]

- - BARRY L. BATZING, State University of New York College at Cortland,
Cortland, New York

DAVID K. COX and STEPHEN B. GOUGH, Environmental Sciences Division,
Oak Ridge National Laboratory, Oak Ridge, Tennessee

Legionnaires' Disease was first recognized in July, 1976. It is caused by "Legionnaires' Disease Bacteria," or LDB. The type species is *Legionella pneumophila*. Only one broad survey of non-epidemic-associated environments for LDB has been made. The presumptive conclusion of this study was that LDB are widely distributed. The present study is one component of a larger survey of waters in the eastern Tennessee region to estimate the occurrence and densities of LDB. The streams in the Great Smoky Mountains National Park were thought to represent primarily pristine waters with little human impact. If LDB were detected in these waters, previous observations of the widespread natural occurrence of LDB in aquatic systems would be supported, and a baseline would be established for comparison to other waters in eastern Tennessee.

Analysis for LDB used membrane filtration in combination with the standard direct fluorescent antibody test for the serogroups of *L. pneumophila* which have been most commonly associated with both clinical and environmental samples. Sixteen water samples were taken at nine stream stations during the fall/winter, 1981-1982. Ten samples had LDB levels less than 3.4 X 10^4/liter. Four samples, representing four sites, had LDB levels in the range of 10^5/liter. The total bacterial count for the water samples, as determined via epifluorescence microscopy in combination with membrane filtration, averaged 1.9 X 10^8 bacteria per liter. LDB thus comprised approximately 0.04% of the average total bacterial population. When compared with water samples obtained from the Tennessee River (Knoxville), the Little Pigeon River (Sevierville), and Melton Hill Lake (between miles 30 and 40), during the same season, there were approximately ten times less total bacteria and LDB per liter in the GSMNP samples. In general, although the data on natural population densities of LDB obtained in this study are lower than those of previous studies, they are in agreement with the concept of widespread natural occurrence of LDB. Summer samples have yet to be collected, however, and trends may differ with increases in temperature, primary productivity, and other variables in these mountain streams.

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[1] Research supported by the Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission, under Interagency Agreement DOE-40-550-75 with the U.S. Department of Energy, under contract W-7405-eng-26

SEASONAL DYNAMICS OF MACROINVERTEBRATE COMMUNITIES OF HIGH ELEVATION STREAMS IN THE BALSAM MOUNTAINS AS A FUNCTION OF PRECIPITATION

- - DOUGLAS G. HOLLAND and J. GERALD ELLER, Western Carolina University, Cullowhee, North Carolina

GARRETT A. SMATHERS, National Park Service, Cooperative Park Studies Unit, Western Carolina University, Cullowhee, North Carolina

High correlation between streamflow and rainfall, fog interception, and canopy throughfall found in this study of factors affecting the seasonal changes in community structure of bethnic macroinvertebrates in headwater areas located in deciduous and spruce/fir forests in the Balsam Mountains is reported. The findings are from an on-going project designed to test three hypotheses: (1) During winter and spring shredder/collectors are codominant with grazers. (2) Grazers are more dominant in the spruce/fir than in the deciduous forest. (3) Significant differences in diversity and density of macroinvertebrates exist between first and second order streams.

INSTREAM FLOW RESEARCH AT OAK RIDGE NATIONAL LABORATORY*

- - M. J. SALE, J. M. LOAR, D. K. COX, and G. F. CADA,
Environmental Sciences Division, Oak Ridge National
Laboratory, Oak Ridge, Tennessee

Instream flow requirements for lotic ecosystems are intended to protect aquatic organisms from the adverse impacts of flow regulation below dams or other water diversion structures. Field research funded by the U. S. Department of Energy is currently being conducted at Oak Ridge National Laboratory on (1) the effects of altered flow regimes on trout populations, and (2) the applicability of existing assessment techniques for instream flow needs to coldwater streams in the southern Appalachians. The purpose of this research is to help resolve the present controversy associated with estimation of minimum releases required at hydroelectric projects.

Eight study sites in four river basins in western North Carolina and eastern Tennessee have been selected on the basis of hydrology, stream channel characteristics, accessibility, and absence of complicating factors such as fishing pressure, stocking, or pollution. Two of these study sites are located on Abrams Creek and Mill Creek within the Great Smoky Mountains National Park. Biological data collected will include fish abundance, food habits of rainbow and brown trout, invertebrate drift, and benthic invertebrate densities. At each site, habitat evaluation models will be applied to investigate the relationship among physical parameters of the stream environment (i.e., the distribution of depth, velocity, bottom substrate, and cover), stream flow, trout production, and other indices of production in lotic systems. The results of these investigations will be used to provide guidance to hydroelectric developers and fisheries managers for selection of appropriate methods for determining minimum flow requirements.

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*This research is supported by the U.S. Department of Energy, Office of Renewable Technology, Geothermal-Hydropower Technology Division. Oak Ridge National Laboratory is operated by Union Carbide Corporation under contract No. W-7405-eng-26 for the U.S. Department of Energy.

THE FISHES OF THE BIG SOUTH FORK NATIONAL RIVER AND RECREATIONAL AREA: SPECIES COMPOSITION, DISTRIBUTION AND THE POTENTIAL FOR A RECREATIONAL FISHERY

- - CHRISTOPHER J. O'BARA and R. DON ESTES, U.S. Fish and Wildlife Service, Tennessee Cooperative Fishery Research Unit, Tennessee Technological University, Cookeville, Tennessee

Sixteen streams were sampled in the Big South Fork National River and Recreational Area for fish and water quality during the summer and fall of 1981. A total of forty-four species of fish were collected representing eight families. The most abundant species included the cyprinids, *Campostoma anomalum* and *Semotilus atromaculatus*; the catostomid, *Hypentelium nigricans*; and the percids, *Etheostoma blennioides* and *Etheostoma caeruleum*. Games species collected included the centrarchids, *Ambloplites rupestris*, *Lepomis macrochirus*, *Lepomis megalotis*, *Micropterus dolomieui* and *Micropterus punctulatus*; and the percid *Stizostedion vitreum*. *Salmo gairdneri* and *Salmo trutta* were collected in two streams and are believed to be a self-reproducing population. The collection of *Ichthyomyzon greeleyi*, *Hybopsis amblops*, *Lepomis gulosus*, *Etheostoma sagitta* and *Aplodinotus grunniens* within the recreational area represents either an extension of their known distribution or the rediscovery of the species. The potential for a viable recreational fishery appears to be limited by a number of adverse land practices within the drainage. Proper environmental protection and management techniques are recommended to improve the recreational fishery within the Big South Fork River and Recreational Area.

ESTABLISHMENT OF BROOK TROUT POPULATIONS IN CUMBERLAND GAP NATIONAL HISTORICAL PARK, KENTUCKY

- - JOHN L. BOAZE, U. S. Fish and Wildlife Service,
Cherokee, North Carolina

In 1968 Shillalah Creek and Martins Fork, Cumberland Gap National Historical Park, Kentucky, were stocked with wild and hatchery-reared brook trout (Salvelinus fontinalis) respectively in an attempt to reestablish this native species. Shillalah Creek received 115 wild fish and Martins Fork was stocked with 500 hatchery-reared trout.

Reproduction was noted in both streams in 1970. In 1972 the two streams were opened to fishing under special regulations. Because of low water conditions fishing was discontinued due to the lack of legal size (greater than 12 inches) fish in 1980. Fishing resumed in 1982 when it was determined that the brook trout population could support fishing.

ANAKEESTA LEACHATE INFLUENCES ON STREAM SYSTEMS FROM ROADCUT VERSUS LANDSLIDE EXPOSURES IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK

- - SCOTT CONE and RAYMOND C. MATHEWS, JR., National Park Service, Uplands Field Research Laboratory, Great Smoky Mountains National Park, Gatlinburg, Tennessee

The recovery rates of stream systems affected by Anakeesta Formation exposed at two different times were studied to determine whether the future recovery of the streams could be predicted. Anakeesta Formation is a geologic complex which occurs widely in the higher elevations in the park and is heavily impregnated with pyritic materials, including aluminum, copper, zinc, magnesium, and lead; and iron sulfide, which, upon exposure, is oxidized to ferrous sulfate and sulfuric acid. Walker Camp Prong (WCP) has been affected by landslide exposures on Mount LeConte for 30 years, which occurred as a result of an extremely heavy rainstorm in September 1951. Beech Flats Creek (BFC) has been affected by roadcut exposures for 20 years, since construction of U.S. Highway 441 was completed in 1963. Aquatic life was eliminated in BFC for approximately 8 km downstream of the exposure. Previous studies show that leachates derived from the Anakeesta during storms lower the receiving stream pH level and alkalinity and raise the acidity, conductivity, hardness, sulfate, and heavy metal concentrations. Benthic macroinvertebrate communities suffer reductions in densities, biomass, diversity, and evenness. Stream data from previous studies (1973-1978) were tabulated and compared with further samples taken in June 1982. Comparisons were then made between the following sets of samples:

1. WCP at 20 years versus BFC at 10 years

2. WCP at 20 years versus WCP at 30 years following exposure

3. BFC at 10 years versus BFC at 20 years following exposure

4. WCP at 20 years versus BFC at 20 years following exposure

BFC had higher pH levels, alkalinity, conductance and sulfate concentrations than WCP. These differences were consistent over all samples taken. The differences in pH level may be caused by the breakdown of feldspars in roadfill rock deposited in or near BFC, which would buffer the acidity, and the formation of $Al(OH)_n$ precipitates, also in BFC, which may buffer the water through amphoteric processes. BFC also had higher concentrations of metals (especially Al, Mg, Zn, and Mn) than WCP and greater reductions in benthic macroinvertebrate populations. Metal determinations and invertebrate samples were only taken in the earlier samples. BFC appeared to recover somewhat between the 1973-1978 samples and the 1982 samples, but not to the level observed in WCP during a similar period after initial exposure. WCP showed little change between 1973-78 and 1982.

Thus it appears that the differences between the streams are sufficient that the recovery rate of BFC is not predictable from observation of WCP. Some trends seem apparent, however, and further research may provide evidence for modeling and predicting recovery mechanisms associated with these complex geochemical activities.

SUMMARY OF TOPIC SESSION--SOCIAL SCIENCE

- - JOHN D. PEINE (Session Chairman), National Park Service, Uplands
Field Research Laboratory, Great Smoky Mountains National Park

National parks are managed to protect natural resources and to provide for the visitor experience. The public plays a key role on both sides of this balanced purpose. Social science is emerging as a valuable set of disciplines which, when applied to management issues, provides insight into developing effective management practices. The papers presented here by John Heywood and Richard Popino represent the application of separate social theory to similar management concerns of quality experience. Bill Hammitt's paper focuses on behavior patterns and their related management implications.

In the future, it is expected that the social science session in this annual meeting will grow as the discipline is further applied in our national parks of the southeastern United States.

A COMPARISON OF WINTER AND SUMMER BACKCOUNTRY USER BEHAVIOR

- - WILLIAM E. HAMMITT and JANET L. LOY, University of Tennessee,
Knoxville, Tennessee

A comparative study was conducted to investigate the use behavior of winter and summer backcountry campers in Great Smoky Mountains National Park. All backcountry studies to date have involved summer users or peak season use. Major objectives of the study were: (1) are the user characteristics and use patterns of winter campers significantly different from summer campers, (2) are the motives for winter camping different than for summer camping, and (3) is area substitution on a seasonal basis a major motive for winter camping in Great Smoky Mountains National Park. Both use permits and a brief mail questionnaire were used for data collection. Approximately 580 winter campers (winter was defined as January and February) and summer campers were sampled by permit. Three-hundred winter users were sampled by questionnaire. Results indicate: (1) place of origin (state), day hike originated (weekend vs. weekday), type of hike (loop vs. non-loop), length of stay, miles hiked, and use areas were all significantly different ($p \leq .05$) between winter and summer users; (2) the "typical" winter backpacker to GSMNP is a male (99%), 30 years of age, has been backpacking for 10 years, averaging 19 days per year, and participates in winter camping significantly more ($p \leq .001$) than he does spring, summer or fall camping; (3) the major motives for winter camping involve "experiencing the winter environment" and "avoiding the summer crowds"; and (4) winter campers to GSMNP definitely substitute other areas for the Park during the heavy use summer season. Thus, while previous backcountry research has shown little evidence for use differences in west versus east users, this may not be the case for summer versus winter users.

NEW RIVER FLOATERS: CONGRUENCE OF MOTIVES AND OUTCOMES WITH PERCEPTIONS OF QUALITY AND SATISFACTION

- - JOHN L. HEYWOOD and DANIEL F. COLLINS, Division of Parks and Recreation Administration, Ohio State University, Columbus, Ohio

The New River, like several western whitewater rivers, has experienced rapid growth in recreational whitewater rafting over the past several years. This situation presented an opportunity to study models which could be useful in establishing management objectives to meet Congressionally mandated goals to establish use limits on the New River National River. Social carrying capacity has been an important concept of particular concern to whitewater river management. Social carrying capacity is based upon logical choice models which assume participants know what they want from a recreational experience, act towards accomplishing their desires, and seek to maximize the satisfaction gained from the experience. Discrepancy theory has provided an important theoretical foundation to the social carrying capacity model. Discrepancy theory holds that satisfaction is a function of the degree to which desired outcomes or motivations are met or exceeded by perceived outcomes. Figure 1 illustrates the theoretical and methodological approach of the New River Study. The study hypothesis was that satisfaction and quality are directly related to the relative congruence of motives and outcomes.

New River floaters were sampled during the summer of 1981. A questionnaire was developed with both motive and outcome scales derived from Drivers (1977) Preferred Outcomes scales. Quality and satisfaction scales were also included. Non-standardized motive/outcome scores were used in the data analysis. These were: 1) nature/solitude, 2) self-awareness/status/autonomy, 3) adventure/enjoyment, and 4) affiliation. The difference in mean motive and mean outcome scores was the measure of congruence. A positive mean refers to a condition where motives are greater than outcomes, and a negative score the opposite. Paired t-tests were used to test the congruence of motives and outcomes with satisfaction and quality.

Generally, the use of non-standardized scores supported a discrepancy model. As satisfaction increased there were more overperformers and fewer underperformers, and the magnitude of overperformance increased. Results for the Satisfied and Very Satisfied groups were all significant at better than the .05 level. For the Not Satisfied group the sample size was too small to show any significant differences. Paired t-tests for quality showed that as quality increased there were fewer underperformers and larger magnitudes of overperformance. It is interesting to note that the most important motive (adventure/enjoyment) goes from a strong underperformer in the group where quality is rated lowest to a point where it is almost a significant overperformer ($p = 0.6$) in the group where quality is rated highest.

This study indicates the New River is currently producing opportunities for access to a significant natural resource through adventuresome, socially-oriented experiences. Current use is providing high quality, satisfying river trip experiences. Significant increases or reductions in use levels would change the experience and the levels of quality and satisfaction. Management goals for the type of New River experience are critical to establishing use limits, and must consider user's motives and outcomes and their perceptions and satisfaction.

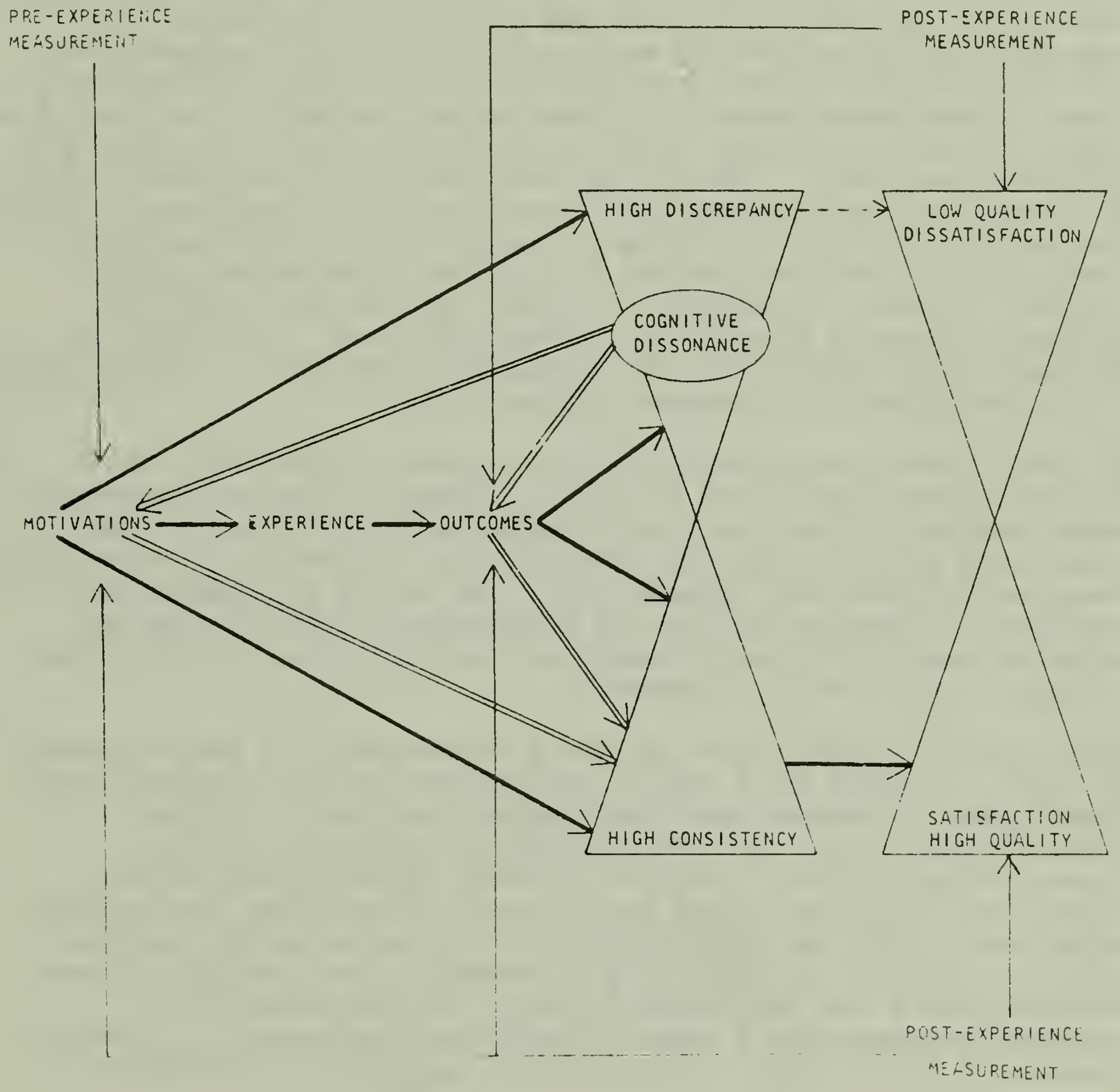
PRE-EXPERIENCE MEASUREMENT
POST-EXPERIENCE MEASUREMENT
HIGH DISCREPANCY
LOW QUALITY DISSATISFACTION
COGNITIVE DISSONANCE
MOTIVATIONS
EXPERIENCE
OUTCOMES
HIGH CONSISTENCY
SATISFACTION HIGH QUALITY
POST-EXPERIENCE MEASUREMENT

Figure 1. - Discrepancy Model and Survey Design

AN ANALYSIS OF THE PREFERENCES AND EXPECTATIONS OF VISITORS TO SHENANDOAH NATIONAL PARK

- - RICHARD W. POPINO and FRED KUSS, Department of Recreation, University of Maryland

One of the ways by which outdoor recreation publics have been characterized has been through the Concept of Experience Levels introduced by R. L. Sanford in 1966. Later modified by Brown et al, the concept has now been incorporated into what is called the Recreation Opportunity Spectrum (ROS). This has resulted in the classification of user publics into a typology of six major groups based upon a number of criteria such as those related to spatial needs, skill level requirements, needs for security, degrees of environmental modification, ease or difficulty of access, degrees of contact with nature, opportunities for socializing and levels of acceptable regimentation. The concept uses a number of criteria which collectively define the types of experiences sought by outdoor recreation publics and identified with different environments which are composed of social, physical and biological components. While this method for classifying user clientele has been adopted by both the U.S. Forest Service and the Bureau of Land Management for outdoor recreational resource planning and management, the concept has not been empirically studied in the context of its original purpose. The concept, likewise, has not been applied to management/planning practices at the National Parks. This study was designed to empirically test the concept when applied to a random sample of visitors attending Shenandoah National Park.

In order to meet the objectives of this study, an Opportunity Level continuum representing five different experience types was constructed which combined criteria devised by Sanford with ROS criteria. These levels were devised within the constraints of the available recreational resources of Shenandoah National Park. Two survey instruments were designed to determine what kind of experiences visitors to the park expected, what kind of experiences they actually perceived at the park and what experiences they preferred.

Results of the study, which included a random sample of 400 respondents initially contacted and a 248 (62 percent) return rate, indicate that significant differences were found between the levels of actual recreation experiences and the expected and preferred levels of recreation experiences. Visitors generally preferred and expected opportunity levels which were lower (less modified) than they actually experienced. This was characteristic of all the variables examined, except for "Levels of Socializing" in which visitors expected to meet more new people than they actually did. Findings indicated that respondents experienced a range of conditions from modern to primitive, from social to solitary. The majority of respondents indicated that they travelled between 51 to 100 miles to reach the park (54.4%) and a majority stated that they visit the park one time per year (55%). The most participated-in activity was "driving on the Skyline Drive" which characterized the heavy implications of the use of automobiles within the park.

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